DOCUMENT RESUME

ED 148 582 SE 023 407

AUTHOR Wagner, David; And Others
TITLE Laboratory Control for Wastewater Facilities, Wastewater Technology: A Two-Year Post High School Instructional Program. Volume III, Parts A, B, C, D, E, F, G.
INSTITUTION Charles County Community Coll., La Plata, Md.; Clemson Univ., S.C.; Greenville Technical Coll., S.C.; Linn-Benton Community Coll., Albany, Oreg.
SPONS AGENCY Environmental Protection Agency, Washington, D.C. Municipal Permits and Operations Div.
PUB DATE Jul 76
NOTE 377p.; For related documents, see SE 023 408-410 and SE 023 432; Contains occasional light type

EDRS PRICE MF-$0.83 HC-$20.75 Plus Postage.
DESCRIPTORS Behavioral Objectives; Curriculum; Environment; *Environmental Technicians; *Instructional Materials; Laboratory Procedures; *Laboratory Techniques; *Pollution; Post Secondary Education; *Water Pollution Control
IDENTIFIERS *Waste Water Treatment

ABSTRACT

This volume is one in a series which outlines performance objectives and instructional modules for a course of study which explains the relationship and function of the process units in a wastewater treatment plant. Examples of modules include measuring settleable matter, total solids, dissolved solids, suspended solids, and volatile solids. The modules are arranged in an order appropriate for teaching students with no experience. They can also be rearranged and adapted for courses to upgrade personnel moving into supervisory positions or designed as a minicourse. Each module contains a statement of purpose, objectives, conditions, acceptable performance, instructor activity and student activity. The tasks are organized in the general categories: normal operations, abnormal operations, preventive maintenance, corrective maintenance, laboratory control, systems interaction, and management/supervisory procedures. Included in this volume are 29 modules. The modules are designed to teach the student laboratory procedures for analyzing various pollutants and variables related to wastewater. Most standard tests are included. (CS)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY
Bernard Lukco
TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC) AND
USERS OF THE ERIC SYSTEM."

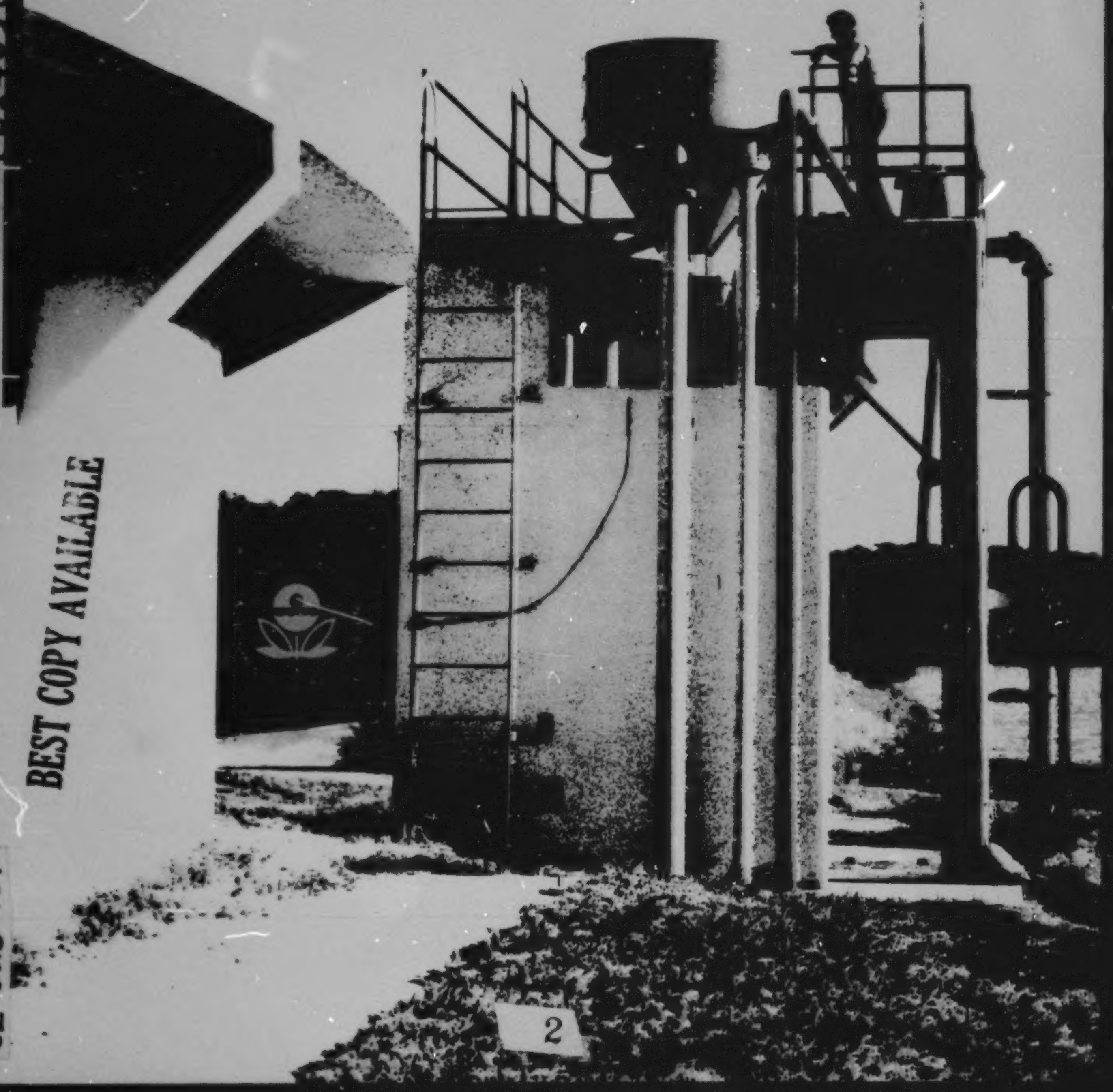
U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Volume III
PART A

EST COPY AVAILABLE

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program



ED148582

BEST COPY AVAILABLE

SE 023 407

LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part A

Standard References
National Pollutant Discharge Elimination System
Safety

An Instructor's Guide for Use of Instructional Material
In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cas lion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page
PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. 11
Module B National Pollutant Discharge Elimination System. 13
Module C Safety 19
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . Part B
Module 3 Chloride . . . . Part B
Module 4 pH . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. . . . . Part C
Module 7 Chemical Oxygen Demand . . . . Part C
Module 8 Chlorine Requirement . . . . Part C
Module 9 Dissolved Oxygen . . . . Part C
Module 10 Fecal Coliform . . . . Part C
Module 11 Total Residual Chlorine. . . . . Part C
Module 12 Color. . . . . Part D
Module 13 Grease . . . . Part D
Module 14 Specific Conductance . . . . Part D
Module 15 Turbidity. . . . . Part D
Module 16 Ammonia Nitrogen . . . . Part E
Module 17 Kjeldahl Nitrogen. Part E
Module 18 Nitrate Nitrogen . . . . Part E
Module 19 Nitrite Nitrogen . . . . Part E
Module 20 Orthophosphate . . . . Part E
Module 21 Total Phosphorus . . . . Part E
Module 22 Settleable Matter. Part F
Module 23 Total Solids . . . . Part F
Module 24 Total Dissolved Solids . . . . Part F
Module 25 Total Suspended Solids . . . . Part F
Module 26 Total Volatile Solids. . . . . Part F
Module 27 Characteristics of Activated Sludge. . . . . Part G
Module 28 Sludge Conditioning. . . . . Part G
Module 29 Sludge Digester Gas. . . . . Part G

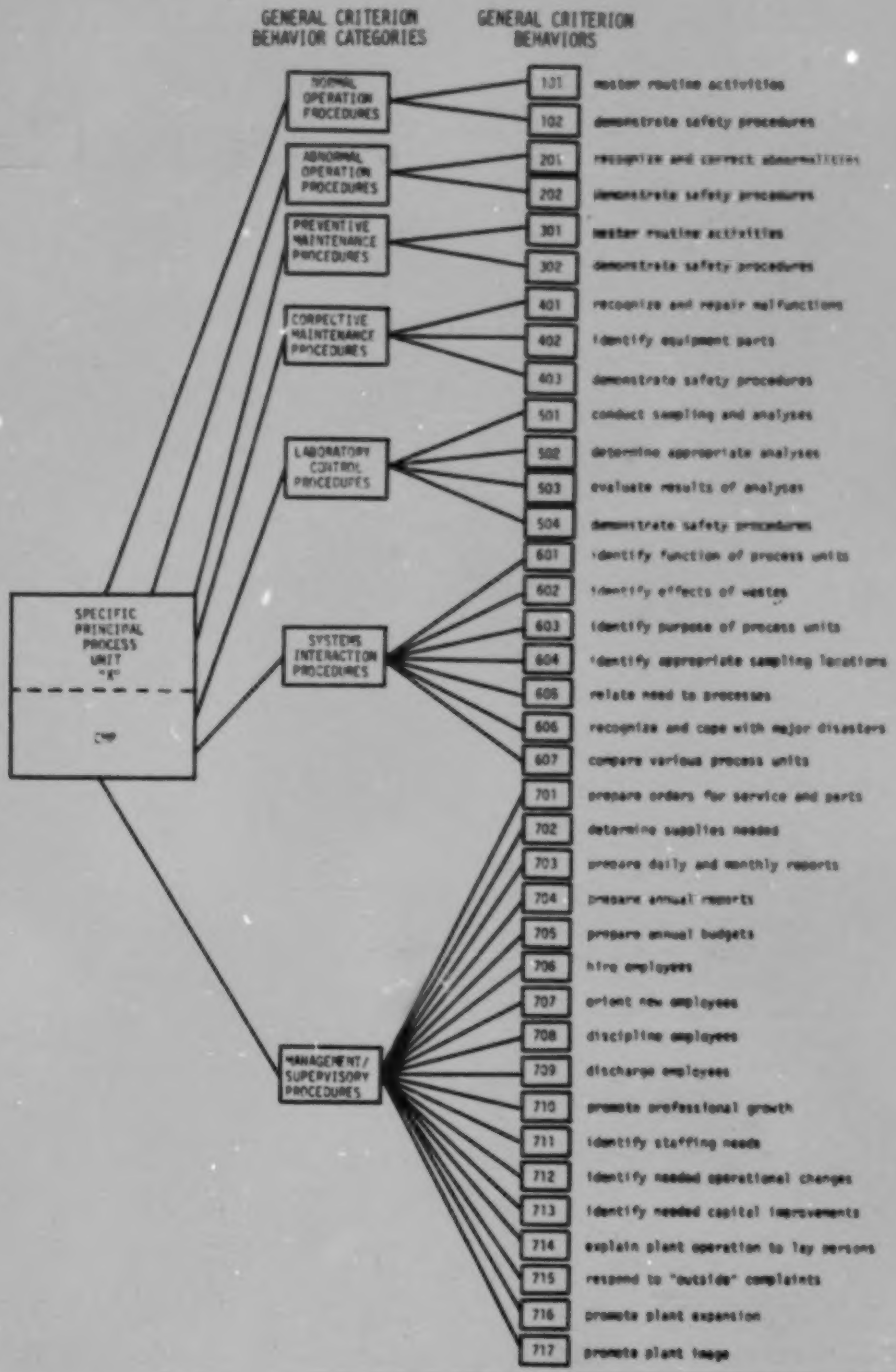

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
NORMAL OPERATION PROCEDURES
101 master routine activities
102 demonstrate safety procedures
ABNORMAL OPERATION PROCEDURES
201 recognize and correct abnormalities
202 demonstrate safety procedures
PREVENTIVE MAINTENANCE PROCEDURES
301 master routine activities
302 demonstrate safety procedures
CORRECTIVE MAINTENANCE PROCEDURES
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
LABORATORY CONTROL PROCEDURES
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
SYSTEMS INTERACTION PROCEDURES
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
MANAGEMENT/ SUPERVISORY PROCEDURES
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant*. If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module A

STANDARD REFERENCES

PURPOSE: *In this module the student will learn to determine which references are used for the wastewater analyses required under the National Pollutant Discharge Elimination System. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

RESOURCES:

4	*Standard Methods for the Examination of Water and Wastewater*, APHA, WPCF, AWWA, ASCE, 16th ed. (1976).
956	*Annual Book of Standards, Part 31, Water*, American Society for Testing and Materials (1976).
2560	*Federal Register*, "Water Programs: Guidelines for Establishing Test Procedures for Analysis of Pollutants," vol. 38, no. 199, pt. 2, Environmental Protection Agency (Oct. 16, 1973).
2612	*Methods for Chemical Analysis of Water and Wastes*, Environmental Protection Agency (1971).

<<<<<<>>>>>>

OBJECTIVE A.1: *List the standard references approved by the Environmental Protection Agency for wastewater analyses.*

CONDITIONS: From memory.

ACCEPTABLE PERFORMANCE: The student will:

List the standard references, including:
Annual Book of Standards
Methods for Chemical Analysis of Water and Wastes
Standard Methods for the Examination of Water and Wastewater

INSTRUCTOR ACTIVITY: 1. Display and name the standard references.

STUDENT ACTIVITY: 1. Note the names of the standard references.

<<<<<<>>>>>>

OBJECTIVE A.2:	*Select the standard references for a wastewater treatment analysis.*
CONDITIONS:	Given a collection of books which includes the resources and a list of wastewater analyses.
ACCEPTABLE PERFORMANCE:	The student will: Locate the analysis in table 1 of "Guidelines Establishing Test Procedures for Analysis of Pollutants." Select the references for the analysis.
INSTRUCTOR ACTIVITY:	1. Name a wastewater analysis. 2. Provide a selection of books on wastewater analyses and treatment.
STUDENT ACTIVITY:	1. Locate the analysis in "Guidelines Establishing Test Procedures for Analysis of Pollutants." 2. Select the references listed in "Guidelines Establishing Test Procedures for Analysis of Pollutants."

<<<<<<>>>>>>

Module B

THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

PURPOSE: *In this module the student will learn to complete discharge monitoring reports required under the National Pollutant Discharge Elimination System (NPDES) permit program and to respond to permit violations. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

RESOURCES:

1289 *Public Law 92-500: Federal Water Pollution Control Act Amendments of 1972,* U.S. Congress (Oct. 18, 1972).

2610 *Orientation to NPDES Permits,* Joseph F. Santner, Environmental Protection Agency (1974).

2611 *Federal Register,* "State Program Elements Necessary for Participation in the National Pollutant Discharge Elimination System," vol. 37, no. 247, pt. 3, Environmental Protection Agency (Dec. 22, 1972).

2726 *Federal Register,* "National Pollutant Discharge Elimination System: Guidelines for Acquisition of Information from Owners of Point Sources," vol. 38, no. 141, pt. 2, Environmental Protection Agency (July 24, 1973).

<<<<<<>>>>>>

OBJECTIVE B.1: *List the information used to complete a discharge monitoring report.*

CONDITIONS: From memory.

ACCEPTABLE PERFORMANCE: The student will:

List the information used to complete a discharge monitoring report, including:
  NPDES permit
  discharge monitoring report form
  laboratory and plant data

INSTRUCTOR ACTIVITY: 1. Display the kinds of information used to complete a discharge monitoring report.

STUDENT ACTIVITY:

1. Examine and note the kinds of information used to complete a discharge monitoring report form.

<<<<<<>>>>>>

OBJECTIVE B.2:

Describe the procedures for completing an NPDES discharge monitoring report.

CONDITIONS:

Given the NPDES permit for a wastewater treatment plant, report forms and laboratory and plant data.

ACCEPTABLE PERFORMANCE:

The student will:

Outline the procedures for completing the report.

INSTRUCTCR ACTIVITY:

1. Explain the procedures for completing the report forms.
2. Check the student's outline.
3. Discuss the laboratory and plant data required for the report.

STUDENT ACTIVITY:

1. Examine the report forms, discussing reporting procedures.
2. Develop an outline of the steps for completing the forms.
3. Practice locating the information needed for a report.

<<<<<<>>>>>>

OBJECTIVE B.3:

Prepare an NPDES discharge monitoring report.

CONDITIONS:

Given the NPDES permit, the discharge monitoring report forms, laboratory and plant data.

ACCEPTABLE PERFORMANCE:

The student will:

Locate the information.

Complete the report forms.

INSTRUCTOR ACTIVITY:

1. Provide laboratory and plant data.
2. Complete sample forms with the help of the student.

STUDENT ACTIVITY:

1. Locate the information needed for the report.
2. Complete the report.

<<<<<<>>>>>>

OBJECTIVE B.4: *Outline the routing and holding procedures for NPDES discharge monitoring reports.*

CONDITIONS: Given the resources and the NPDES permit for a wastewater treatment plant.

ACCEPTABLE PERFORMANCE: The student will:

Outline the routing and holding procedures for NPDES discharge monitoring reports, commenting on the role of the:
  plant manager
  state agency
  EPA regional administrator

INSTRUCTOR ACTIVITY:

1. Discuss the routing and holding procedures for NPDES discharge monitoring reports.
2. Discuss the role of the plant manager, the state agency and the EPA regional administrator in the routing and holding procedures for NPDES discharge monitoring reports.

STUDENT ACTIVITY:

1. Outline the routing and holding procedures for NPDES discharge monitoring reports.
2. Describe the role of the plant manager, the state agency and the EPA regional administrator in the routing and holding procedures for NPDES discharge monitoring reports.

<<<<<<>>>>>>

OBJECTIVE B.5: *Describe the circumstances under which a treatment plant may deviate from its permit and how to obtain permission.*

CONDITIONS: Given the resources and the NPDES permit for a wastewater treatment plant.

ACCEPTABLE PERFORMANCE: The student will:

Describe the circumstances under which a wastewater treatment plant manager would request permission to deviate from the requirements of the permit, commenting on:
  sampling procedures
  analytical procedures
  report procedures

Describe the procedures for obtaining permission.

INSTRUCTOR ACTIVITY:

1. Describe the circumstances under which a plant may deviate from its permit.
2. Describe the procedures for obtaining permission.
3. Present case histories of plant discharges under the NPDES permitting system.
4. Describe problems of plants not meeting the requirements of their permits.

STUDENT ACTIVITY:

1. Discuss the circumstances under which a plant may deviate from its permit.
2. Outline the procedures for obtaining permission.
3. Evaluate the action taken by the plant manager.
4. Decide whether permission for deviation from the permit is required and describe the procedures for obtaining permission.

<<<<<<>>>>>>

OBJECTIVE B.6: *Describe the actions of a treatment plant operator when permit requirements are violated.*

CONDITIONS: Given the references and the NPDES permit for a wastewater treatment plant.

ACCEPTABLE PERFORMANCE: The student will:

Describe the procedures for handling these violations:
  a one-time violation, a small percentage over the permit limit
  a repeated violation, a small percentage over the permit limit
  a one-time violation, grossly over the limit
  a repeated violation, grossly over the limit

Describe the effects of revising sampling schedules.

Describe the consequences of remaining in violation of the permit, including:
  permit cancellation
  court actions
  fines

INSTRUCTOR ACTIVITY:

1. Discuss the procedures for handling permit violations.
2. Present case histories of permit violations.
3. Discuss penalties for remaining in violation of the permit.

STUDENT ACTIVITY:

1. Describe the procedures for handling permit violations.
2. Discuss the disposition of the violation, including in-plant changes.
3. Describe penalties for permit violation.

<<<<<<>>>>>>

Module C

SAFETY

PURPOSE: *In this module the student will learn to recognize dangerous situations and activities in the laboratory of the wastewater treatment plant and to use proper techniques when performing high-risk activities. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

RESOURCES:

225 387 465 636 833 866 938 939 940 942 951 952
1033 1034 1123 1124 1125 1126 1127 1128 1326 1336 1342 1370
1433 1461 1473 1511 1594

<<<<<<>>>>>>

OBJECTIVE C.1: *State the rules governing behavior in the laboratory.*

CONDITIONS: Given photographs of laboratory technicians at work or a laboratory in which technicians are at work.

ACCEPTABLE PERFORMANCE: The student will:

Identify actions and situations which violate laboratory rules related to:
- eating
- general behavior
- monitoring dangerous procedures
- protecting the face and hands
- smoking

State the rules governing laboratory behavior which apply in each situation.

INSTRUCTOR ACTIVITY:

1. Discuss rules governing laboratory behavior, using visuals of technicians in the laboratory.

STUDENT ACTIVITY:

1. Evaluate the behavior of technicians observed in visuals. State the rule which applies.

<<<<<<>>>>>>

OBJECTIVE C.2: *Locate laboratory safety equipment.*

CONDITIONS: Given a wastewater treatment plant and a list of the safety equipment.

ACCEPTABLE PERFORMANCE: The student will:

Locate this emergency safety equipment:
- dilution solutions
- emergency telephone numbers
- eye-and-face wash
- fire blanket
- fire extinguisher
- first-aid cabinet
- safety shower

Locate this safety equipment:
- apron
- fume hood
- glasses
- gloves
- pipet bulbs
- asbestos boards
- gas cylinder supports
- laboratory carts
- safety visor
- tongs

INSTRUCTOR ACTIVITY:

1. Point out the location of safety equipment used during emergencies.
2. Point out the location of safety equipment used during analyses.

STUDENT ACTIVITY:

1. Practice getting to the location of the emergency equipment as quickly as possible.
2. Locate the safety equipment used during analyses.

<<<<<<>>>>>>

OBJECTIVE C.3: *Demonstrate the use of laboratory safety equipment used for emergencies.*

CONDITIONS: Given a description of a laboratory accident or a simulated accident and a wastewater treatment plant laboratory.

ACCEPTABLE PERFORMANCE: The student will:

Use a fire extinguisher.

Use a fire blanket.

Apply a tourniquet.

Apply bandages.

Use a safety shower.

Use an eye-and-face wash.

Make an emergency telephone call.

Dilute an acid spill.

INSTRUCTOR ACTIVITY:

1. Present case histories of accidents in wastewater treatment plant laboratories.
2. Describe laboratory emergencies.
3. Set up simulated accidents in the laboratory.

STUDENT ACTIVITY:

1. Comment on the safety procedures used.
2. Describe the actions of the laboratory technician during these emergencies.
3. Demonstrate the safety procedures for the simulated accidents.

<<<<<<>>>>>>

OBJECTIVE C.4: *Point out dangerous substances and materials in the laboratory.*

CONDITIONS: Given photographs of laboratory technicians at work or a laboratory in which technicians are at work.

ACCEPTABLE PERFORMANCE: The student will:

Point out dangerous substances, including:
  broken glass
  compressed gases
  corrosive chemicals
  explosive materials
  hot containers
  infectious materials
  toxic materials
  volatile solvents

INSTRUCTOR ACTIVITY:

1. Display and describe dangerous substances and materials in the laboratory.
2. Present visuals of technicians working with dangerous substances and materials.

STUDENT ACTIVITY:

1. List dangerous substances and materials.
2. Point out the dangerous substances and materials which technicians are using.

<<<<<<>>>>>>

OBJECTIVE C.5: *Describe the safety procedures for handling dangerous substances and materials in the laboratory.*

CONDITIONS: Given photographs of laboratory technicians at work or a laboratory in which technicians are at work and a list of dangerous substances and materials.

ACCEPTABLE PERFORMANCE: The student will:

Describe the safety procedures for handling dangerous substances and materials, commenting on:

flame polishing glassware
inoculations
labeling chemicals
labeling hot containers
storage and disposal of broken glassware
storing chemicals
storing gas cylinders
using a vented hood
using insulating materials
ventilation and lighting of storage areas

INSTRUCTOR ACTIVITY:

1. Discuss case histories of accidents in wastewater treatment plant laboratories.
2. Describe the conditions in a laboratory and ask for evaluation.
3. Present visuals of laboratory procedures.

STUDENT ACTIVITY:

1. Comment on the safety procedures.
2. Evaluate conditions which the instructor has described. Suggest safety procedures.
3. Comment on the safety procedures for handling dangerous substances and materials.

<<<<<<>>>>>>

OBJECTIVE C.6: *Point out high-risk laboratory activities and describe the kinds of injuries they cause.*

CONDITIONS: Given photographs of laboratory technicians at work or a laboratory in which technicians are at work.

ACCEPTABLE PERFORMANCE: The student will:

Point out high-risk activities, including:
- exposure to toxic materials
- handling chemicals
- handling glassware
- pipetting liquids
- sampling and handling infectious materials
- using gas and compressed air
- using mechanical equipment
- working in poorly ventilated areas

Describe the injuries associated with these activities.

INSTRUCTOR ACTIVITY:

1. Discuss high-risk laboratory activities and the injuries they cause.
2. Present visuals of technicians performing high-risk activities.

STUDENT ACTIVITY:

1. List high-risk laboratory activities and the injuries they cause.
2. Point out high-risk activities and describe the injuries associated with them.

<<<<<<>>>>>>

OBJECTIVE C.7: *Perform the high-risk activities.*

CONDITIONS: Given a list of high-risk activities and a wastewater treatment plant laboratory.

ACCEPTABLE PERFORMANCE: The student will:

Perform the high-risk activities, including these actions and precautions:
- cleaning up spills
- diluting acid
- following directions for using machinery and instruments

handling explosive materials
making rubber to glass connections
monitoring reactions
reading labels
smelling chemicals
using a fume hood
using a heating mantle
using asbestos gloves and tongs
using boiling chips
using spatulas, spoons and tongs
using suction bulbs
ventilating the laboratory
wearing protective clothing

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedures for performing high-risk activities.
2. Present visuals of technicians performing high-risk activities.
3. Evaluate the student's performance with the help of other students.

STUDENT ACTIVITY:

1. Observe the instructor.
2. Evaluate the performance of the technicians.
3. Perform the high-risk activities.

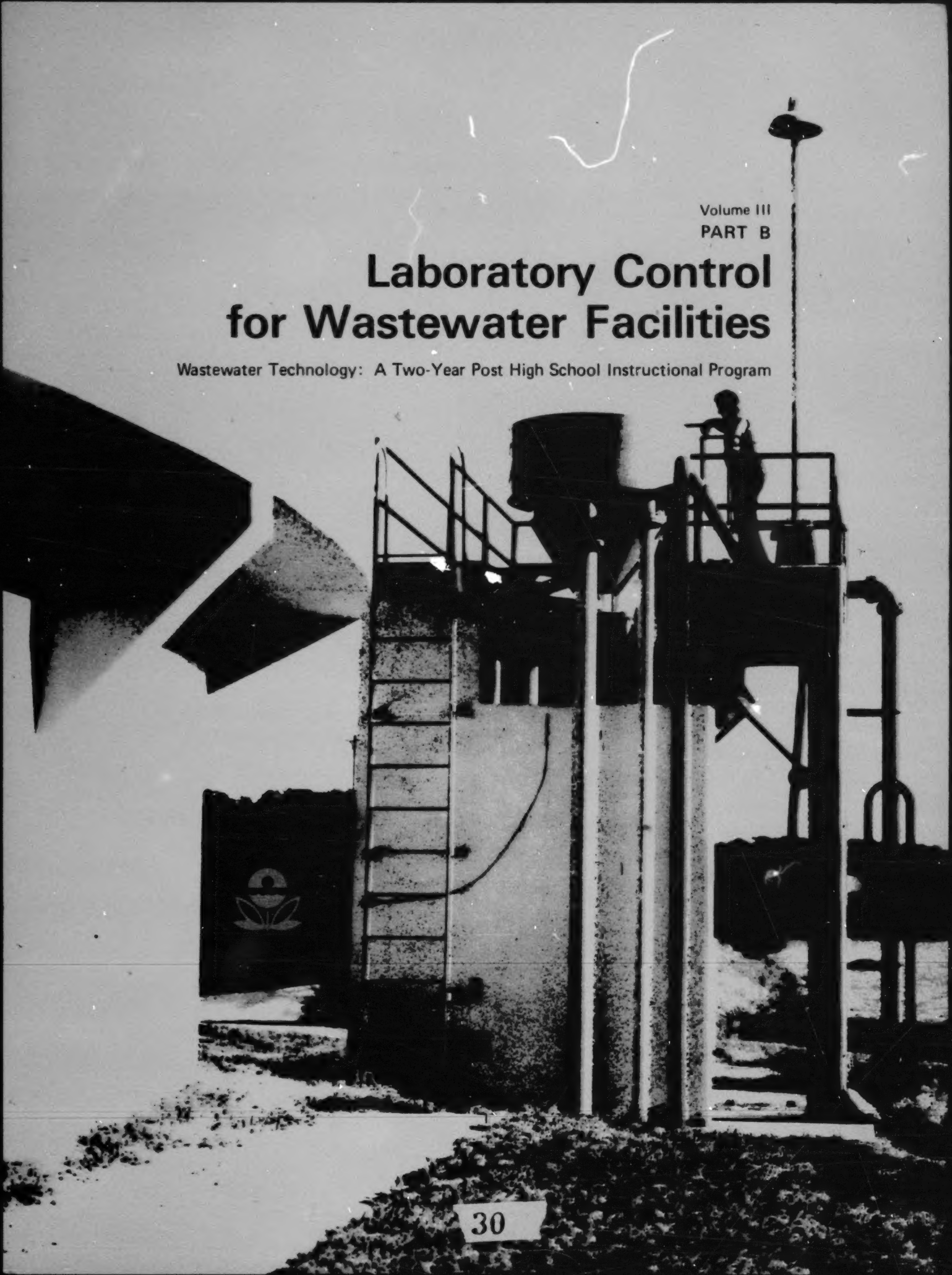
<<<<<<>>>>>>

Volume III

PART B

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program



LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part B

Acidity
Alkalinity
Chloride
pH
Temperature

An Instructor's Guide for Use of Instructional Material In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page

PREFACE . . . iii
PERFORMANCE OBJECTIVES . . . 1
INTRODUCTION TO MODULES OF INSTRUCTION . . . 3
GLOSSARY OF VERBS . . . 7

MODULES OF INSTRUCTION

Module A Standard References . . . Part A
Module B National Pollutant Discharge Elimination System . . . Part A
Module C Safety . . . Part A
Module 1 Acidity . . . 11
Module 2 Alkalinity . . . 23
Module 3 Chloride . . . 33
Module 4 pH . . . 43
Module 5 Temperature . . . 53
Module 6 Biochemical Oxygen Demand . . . Part C
Module 7 Chemical Oxygen Demand . . . Part C
Module 8 Chlorine Requirement . . . Part C
Module 9 Dissolved Oxygen . . . Part C
Module 10 Fecal Coliform . . . Part C
Module 11 Total Residual Chlorine . . . Part C
Module 12 Color . . . Part D
Module 13 Grease . . . Part D
Module 14 Specific Conductance . . . Part D
Module 15 Turbidity . . . Part D
Module 16 Ammonia Nitrogen . . . Part E
Module 17 Kjeldahl Nitrogen . . . Part E
Module 18 Nitrate Nitrogen . . . Part E
Module 19 Nitrite Nitrogen . . . Part E
Module 20 Orthophosphate . . . Part E
Module 21 Total Phosphorus . . . Part E
Module 22 Settleable Matter . . . Part F
Module 23 Total Solids . . . Part F
Module 24 Total Dissolved Solids . . . Part F
Module 25 Total Suspended Solids . . . Part F
Module 26 Total Volatile Solids . . . Part F
Module 27 Characteristics of Activated Sludge . . . Part G
Module 28 Sludge Conditioning . . . Part G
Module 29 Sludge Digester Gas . . . Part G

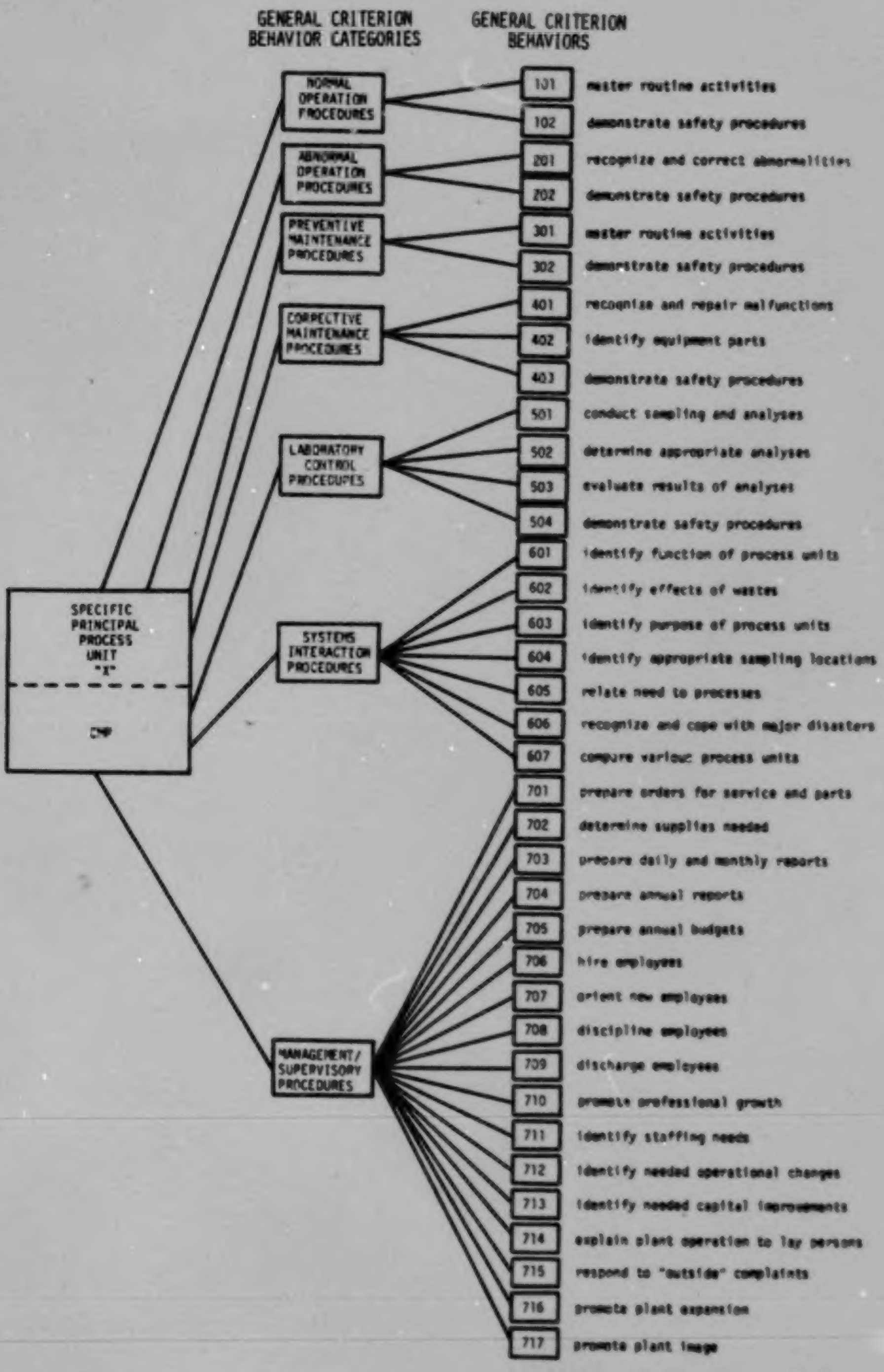

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
NORMAL OPERATION PROCEDURES
ABNORMAL OPERATION PROCEDURES
PREVENTIVE MAINTENANCE PROCEDURES
CORRECTIVE MAINTENANCE PROCEDURES
LABORATORY CONTROL PROCEDURES
SYSTEMS INTERACTION PROCEDURES
MANAGEMENT/ SUPERVISORY PROCEDURES
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
101 master routine activities
102 demonstrate safety procedures
201 recognize and correct abnormalities
202 demonstrate safety procedures
301 master routine activities
302 demonstrate safety procedures
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant*. If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 1

ACIDITY

PURPOSE: *In this module the student will learn to determine the acidity of a sample of wastewater by using the indicator method and the potentiometric method. These analyses measure the acid in the wastestream by titration with a standard base. Acidic waters are corrosive and corrosion control is expensive. Acidity measurements can indicate a change in the composition of the wastestream if it is known to have generally stable levels of acidity. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A and module 4 on pH, page 43.*

OBJECTIVES:

1.1 Describe the sampling procedures for the acidity analysis.
1.2 Perform the sampling procedures for the acidity analysis.
1.3 Describe the indicator and potentiometric methods for acidity analysis.
1.4 Perform the acidity analysis.
1.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
1.6 Plan the laboratory control procedures for monitoring acidity.
1.7 Explain the theory behind the acidity analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
bromcresol green-methyl red indicator	x	
carbon-dioxide free distilled water	x	
methyl orange indicator	x	
phenolphthalein indicator	x	
potassium biphthalate, 0.02*N*	x	
sodium hydroxide, 0.02*N*	x	
sodium thiosulfate, 0.1*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
buret caps	x	
buret clamps	x	
burets, 50 ml	x	
Erlenmeyer flasks, 250 ml	x	
funnels	x	
graduated cylinders, 100 ml	x	
hot plate	x	
pH meter	x	
pipets, volumetric, 25, 50 and 100 ml	x	
refrigerator		x
ring stands	x	
rubber bulbs	x	
volumetric flasks, 1 liter	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 1.1: *Describe the sampling procedures for the acidity analysis.*

CONDITIONS: Given *Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 148* and these plant locations for grab and composite samples:
- influent
- first stage digester
- second stage digester

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 1.2: *Perform the sampling procedures for the acidity analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepere and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 1.3a: *Describe the indicator method for acidity analysis.*

CONDITIONS: Given a standard reference, the formula for calculating acidity and acidity data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for pipetting samples and preparing standard sodium hydroxide titrant.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
standardization of titrant
titration to methyl orange end point
titration to phenolphthalein end point

Describe the end points in the titration procedure.

Describe the procedures for recording data.

Calculate the acidity.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for pipetting samples and preparing standard sodium hydroxide titrant.
3. Describe the major steps in the acidity analysis and describe the color changes at the end points.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating acidity, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when pipetting and preparing standard sodium hydroxide titrant.
3. List the major steps in the analysis and describe the color changes at the end points of titration.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 1.3b: *Describe the potentiometric method for acidity analysis.*

CONDITIONS: Given a standard reference, the formula for calculating acidity and acidity data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for pipetting samples and preparing standard sodium hydroxide titrant.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  addition of the titrant
  recording of relative pH

Describe the procedures for recording data.

Describe preparation of the titration curve and how to obtain data from it.

Calculate the acidity.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for pipetting samples and preparing standard sodium hydroxide titrant.
3. Describe the steps in the acidity analysis.
4. Explain the procedures for recording data.
5. Describe preparation of the titration curve and how to obtain data from it.
6. Check the flow chart for the analysis which the student has prepared.
7. Present the formula for calculating acidity, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when pipetting and preparing standard sodium hydroxide titrant.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Describe the preparation of a titration curve and how to obtain data from it.
6. Develop a flow chart for the analysis.
7. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 1.4a: *Perform the acidity analysis on a sample using the indicator method.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the acidity and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the acidity and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the samples for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 1.4b: *Perform the acidity analysis on a sample using the potentiometric method.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the acidity and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the acidity and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 1.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.*

CONDITIONS: Given references and the results of acidity analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal acidity levels found in these unit processes:
  collection
  first stage digestion
  second stage digestion

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal acidity levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal acidity levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 1.6: *Plan the laboratory control procedures for monitoring acidity.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for acidity.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring acidity.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring acidity.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for acidity.
2. Describe sampling locations and the frequency and methods of analysis for monitoring acidity.
3. Discuss requirements for equipment, storage, records and reports for monitoring acidity.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for acidity.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring acidity.
3. Discuss requirements for equipment, storage, records and reports for monitoring acidity.
4. Work in small groups to plan the laboratory control procedures for monitoring acidity.

<<<<<<>>>>>>

OBJECTIVE 1.7: *Explain the theory behind the acidity analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Define acidity.

Describe the role of the indicators and how they are chosen.

Explain how acidity results will be affected by:
- aluminum sulfate
- free available residual chlorine
- iron
- titrating at below boiling temperatures

Describe the advantages of the potentiometric method over the indicator method.

State the acid-base reaction equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain acidity.
2. Discuss the indicators.
3. Discuss the effects of interferences and improper procedures on analysis results.
4. Compare the two methods of analysis.
5. Present the acid-base reaction equations, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Define acidity.
2. Describe the role of the indicators and how they are chosen.
3. Explain the effects of interferences and improper procedures on analysis results.
4. Describe the advantages of the potentiometric method.
5. State the acid-base reaction equations, explaining the reactions taking place during the analysis.

<<<<<<>>>>>>

Module 2

ALKALINITY

PURPOSE: *In this module the student will learn to determine the alkalinity of a sample of wastewater by using the titrimetric method. This analysis measures the bicarbonates, carbonates and hydroxides in the wastestream by titration with a strong mineral acid. Abnormal alkalinity levels can indicate the presence of alkaline industrial wastes. Results of the analysis are used in water softening and in the control of chemical coagulation, corrosion and anaerobic digestion. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A and module 4 on pH, page 43.*

OBJECTIVES:

2.1 Describe the sampling procedures for the alkalinity analysis.
2.2 Perform the sampling procedures for the alkalinity analysis.
2.3 Describe the titrimetric method for alkalinity analysis.
2.4 Perform the alkalinity analysis.
2.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of alkalinity analyses.
2.6 Plan the laboratory control procedures for monitoring alkalinity.
2.7 Explain the theory behind the alkalinity analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
bromcresol green-methyl red indicator	x	
carbon-dioxide free distilled water	x	
methyl orange indicator	x	
phenolphthalein indicator	x	
sodium thiosulfate, 0.1*N*	x	
sulfuric acid or hydrochloric acid, 0.02*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
buret caps	x	
buret clamps	x	
burets, 50 ml	x	
drying oven	x	
Erlenmeyer flasks, 250 ml	x	
funnels	x	
graduated cylinders, 100 ml	x	
hot plate	x	
pH meter	x	
pipets, volumetric, 25, 50 and 100 ml	x	
refrigerator		x
ring stands	x	
rubber bulbs	x	
volumetric flasks, 1 liter	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 413 465 466 488 833 866 1027 1033 1034 1079
1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 2.1: *Describe the sampling procedures for the alkalinity analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 370; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 143; Method for Chemical Analysis of Water and Wastes, p. 6;* and these plant locations for grab and composite samples:

- thickener
- first stage digester
- second stage digester
- sludge conditioner
- sludge dewaterer

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place

time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 2.2: *Perform the sampling procedures for the alkalinity analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 2.3: *Describe the titrimetric method for alkalinity analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating alkalinity and alkalinity data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing standard sulfuric or hydrochloric acid titrant and for pipetting samples.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  standardization
  titration

Describe the end points in the titration procedure.

Describe the procedures for recording data.

Calculate the alkalinity.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for preparing standard sulfuric or hydrochloric acid titrant and for pipetting samples.
3. Describe the steps in the alkalinity analysis and describe the end points in the titration procedure.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating alkalinity, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing standard sulfuric or hydrochloric acid titrant and for pipetting samples.
3. List the major steps in the analysis and describe the end points in the titration procedure.
4. List the procedures for recording data.
5. Develop a flow chart for the alkalinity analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 2.4: *Perform the alkalinity analysis.*

CONDITIONS: Given a standard reference, a laboratory with [illegible]ent and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the alkalinity and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the alkalinity and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 2.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of alkalinity analyses.

CONDITIONS:

Given references and the results of alkalinity analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal alkalinity levels found in these unit processes:
thickening
first stage digestion
second stage digestion
sludge conditioning
sludge dewatering

Describe what to do if the results of the analyses are not within the normal range, including:
increasing the frequency of testing
sampling at different locations
reporting to supervisors

Determine which of these factors causes a departure from normal levels:
changes in the composition of the wastestream
changes in treatment
errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal alkalinity levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal alkalinity levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 2.6: *Plan the laboratory control procedures for monitoring alkalinity.*

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for alkalinity.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring alkalinity.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring alkalinity.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for alkalinity.
2. Describe sampling locations and the frequency and methods of analysis for monitoring alkalinity.
3. Discuss requirements for equipment, storage, records and reports for monitoring alkalinity.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for alkalinity.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring alkalinity.
3. Discuss requirements for equipment, storage, records and reports for monitoring alkalinity.
4. Work in small groups to plan the laboratory control procedures for monitoring alkalinity.

<<<<<<>>>>>>

OBJECTIVE 2.7:

Explain the theory behind the alkalinity analysis.

CONDITIONS:

Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Define alkalinity.

Describe the role of the indicators and how they are chosen.

Explain how alkalinity results will be affected by:
- calcium carbonate
- free available residual chlorine
- magnesium hydroxide
- salts of weak inorganic and organic acids

State the acid-base reaction equations, explaining the reactions during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain alkalinity.
2. Discuss the indicators.
3. Discuss the causes and effects of interferences.
4. Present the acid-base reaction equations, explaining the reactions during the analysis.

STUDENT ACTIVITY:

1. Define alkalinity.
2. Describe the role of the indicators and how they are chosen.
3. Explain the effects of interferences.
4. State the acid-base reaction equations, explaining the reactions during the analysis.

<<<<<<>>>>>>

Module 3

CHLORIDE

PURPOSE: *In this module the student will learn to determine the amount of chloride in a sample of wastewater by using the mercuric nitrate method. This analysis measures the chloride in the wastestream by titration with mercuric nitrate. Chloride, one of the major anions in wastewater, promotes corrosion which is expensive to control. Wastewater with a high chloride content cannot be used for irrigation because it adversely affects the growth of crops. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

3.1 Describe the sampling procedures for the chloride analysis.
3.2 Perform the sampling procedures for the chloride analysis.
3.3 Describe the mercuric nitrate method for chloride analysis.
3.4 Perform the chloride analysis.
3.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of chloride analyses.
3.6 Plan the laboratory control procedures for monitoring chloride.
3.7 Explain the theory behind the chloride analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
bromphenol blue indicator	x	
distilled water	x	
ethyl alcohol or isopropyl alcohol	x	
mercuric nitrate, 0.0141N and 0.141N	x	
nitric acid, 0.1N and concentrated	x	
s-diphenylcarbazone	x	
sodium bicarbonate	x	
sodium chloride	x	
sodium hydroxide, 0.1N	x	
xylene cyanol FF	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
buret, 25 ml	x	
buret caps	x	
buret clamps	x	
Erlenmeyer flasks, 250 ml	x	
graduated cylinders	x	
pH meter	x	
pipets, measuring, 5 ml	x	
pipets, volumetric, 5, 50 and 100 ml	x	
refrigerator	x	x
ring stands	x	
rubber bulbs	x	
stirring rods	x	
volumetric flasks, 1 liter	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 700 702 833 866 1033 1034 1079 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 3.1: *Describe the sampling procedures for the chloride analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater*, p. 37; *Annual Book of Standards Part 31, Water, Atmospheric Analysis*, p. 21; *Method for Chemical Analysis of Water and Wastes*, p. 31; and these plant locations for grab and composite samples:
   influent
   effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 8.2: *Perform the sampling procedures for the chloride analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.

2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 3.3: *Describe the mercuric nitrate method for chloride analysis.*

CONDITIONS: Given a standard reference, the formula for calculating chloride and chloride data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing standard mercuric nitrate titrant and pipetting samples.

Explain how these safety precautions protect employees.

List the major steps in the analysis;
  standardization of titrant
  titration

Describe the end point in the titration procedure.

Describe the procedures for recording data.

Calculate the chloride.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.

2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for preparing standard mercuric nitrate titrant and pipetting samples.
3. Describe the steps in the chloride analysis and describe the end point in the titration procedure.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating chloride, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing standard mercuric nitrate titrant and pipetting samples.
3. List the major steps in the analysis and describe the color changes at the end point in the titration procedure.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 3.4: *Perform the chloride analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the chloride and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.

3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the chloride and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 3.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of chloride analyses.*

CONDITIONS: Given references and the results of chloride analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal chloride levels found in these unit processes:
  collection
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal chloride levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal chloride levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of the analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 3.6: *Plan the laboratory control procedures for monitoring chloride.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for chloride.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring chloride.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring chloride.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for chloride.
2. Describe sampling locations and the frequency and methods of analysis for monitoring chloride.
3. Discuss requirements for equipment, storage, records and reports for monitoring chloride.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for chloride.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring chloride.
3. Discuss requirements for equipment, storage, records and reports for monitoring chloride.
4. Work in small groups to plan the laboratory control procedures for monitoring chloride.

<<<<<<>>>>>>

OBJECTIVE 3.7: Explain the theory behind the chloride analysis.

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Explain how chloride results will be affected by:
- bromide
- chromate ions
- ferric ions

iodide
sulfite ions

Describe the role of the indicator.

State the oxidation-reduction reaction equation, explaining the reactions during the analysis. Name the substances being oxidized and reduced in this equation.

INSTRUCTOR ACTIVITY:

1. Discuss the causes and effects of interferences.
2. Discuss the indicator.
3. Present the oxidation-reduction reaction equation, explaining the reactions during the analysis. Name the oxidizing and reducing agents.

STUDENT ACTIVITY:

1. Explain the effects of interferences.
2. Discuss the role of the indicator.
3. State the oxidation-reduction reaction equation, explaining the reactions during the analysis. Name the oxidizing and reducing agents.

<<<<<<>>>>>>

Module 4

pH

PURPOSE: *In this module the student will learn to determine the pH of a sample of wastewater by using the glass electrode method. This analysis measures the concentration of hydroxide ions. Results of the analysis are used in chemical coagulation, disinfection, water softening and corrosion control. Unusually strong acid or alkaline wastes can damage sewer lines and process units and interfere with biological processes, such as activated sludge treatment or trickling filtration. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

4.1 Describe the sampling procedures for the pH analysis.
4.2 Perform the sampling procedures for the pH analysis.
4.3 Describe the glass electrode method for pH analysis.
4.4 Perform the pH analysis.
4.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of pH analyses.
4.6 Plan the laboratory control procedures for monitoring pH.
4.7 Explain the theory behind the pH analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
buffer solution, pH 4.00	x	
buffer solution, pH 7.00	x	
buffer solution, pH 10.00	x	
calcium hydroxide solution, saturated	x	
distilled water	x	
potassium hydrogen tartrate solution, saturated	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 100 ml	x	
drying oven	x	
electrode, reference	x	
electrode, glass	x	
hot plate	x	
pH meter	x	
thermometer	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES:

142 225 387 465 488 577 578 833 866 1027 1033 1034
1063 1076 1079 1080 1125 1326 1336 1370 1461 1473 1512 1513
1757 1758 1762

<<<<<<>>>>>>

OBJECTIVE 4.1: *Describe the sampling procedures for the pH analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 276; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 186; Method for Chemical Analysis of Water and Wastes, p. 230;* and these plant locations for composite samples:
  chlorinator
  screen and grinder effluent
  grit chamber
  primary sedimentation tank
  trickling filter underdrain
  aerator
  secondary sedimentation tank
  pond
  thickener
  first stage digester
  second stage digester
  sludge conditioner
  sludge dewaterer
  effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
  date
  place

time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling at each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 4.2: *Perform the sampling procedures for the pH analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.

2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
4. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Demonstrate the sampling procedures in a dry run in the laboratory.
4. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 4.3: *Describe the glass electrode method for pH analysis.*

CONDITIONS: Given a standard reference.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for using a pH meter and preparing buffer solutions.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  calibration of the pH meter
  pH determination

Explain the significance of having the pH meter, buffer solutions and samples at the same temperature.

Describe the procedures for recording data.

Read the pH meter.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for using a pH meter and preparing buffer solutions.

3. Describe the steps in the pH analysis and explain the significance of having the pH meter, buffer solutions and samples at the same temperature.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Display the pH meter. Explain how to take pH readings.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when using a pH meter and preparing buffer solutions.
3. List the major steps in the analysis and explain the significance of having the pH meter, buffer solutions and samples all at the same temperature.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Practice reading the pH meter.

<<<<<<>>>>>>

OBJECTIVE 4.4: *Perform the pH analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the pH and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laborator .

7. Explain how to read the pH meter, record data and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 4.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of pH analyses.*

CONDITIONS: Given references and the results of pH analyses.

ACCEPTABLE PERFORMANCE: The student will:

Obtain the references and determine normal pH levels found in these unit processes:
  chlorination
  screening and grinding
  grit removal
  primary sedimentation
  trickling filtration
  aeration
  secondary sedimentation
  pond stabilization
  thickening
  first stage digestion
  second stage digestion
  sludge conditioning
  sludge dewatering
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment

errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal pH levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal pH levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a . certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 4.6: *Plan the laboratory control procedures for monitoring pH.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for pH.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring pH.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring pH.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for pH.
2. Describe sampling locations and the frequency and methods of analysis for monitoring pH.
3. Discuss requirements for equipment, storage, records and reports for monitoring pH.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for pH.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring pH.
3. Discuss requirements for equipment, storage, records and reports for monitoring pH.
4. Work in small groups to plan the laboratory control procedures for monitoring pH.

<<<<<<>>>>>>

OBJECTIVE 4.7: *Explain the theory behind the pH analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Define pH.

Explain why the glass electrode method is most commonly used.

Explain how pH results will be affected by changes in temperature and by high sodium ion concentrations and how these can be avoided.

Describe the use of buffer solutions.

INSTRUCTOR ACTIVITY:

1. Explain pH.
2. Explain why the glass electrode method is most commonly used.
3. Discuss the causes and effects of interferences.
4. Discuss the use of buffer solutions.

STUDENT ACTIVITY:

1. Define pH.
2. Explain why the glass electrode method is most commonly used.
3. Explain the effects of interferences.
4. Explain the use of buffer solutions.

<<<<<<>>>>>>

Module 5

TEMPERATURE

PURPOSE: *In this module the student will learn to determine the temperature of a sample of wastewater by using a centigrade thermometer. The temperature of the wastestream affects the rate of treatment processes. As the temperature of water rises, the amount of oxygen it can hold decreases. In general, a ten degree centigrade increase in temperature causes a doubling of biological activity in biological treatment processes. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

5.1 Describe the sampling procedures for the temperature analysis.
5.2 Perform the sampling procedures for the temperature analysis.
5.3 Describe the method for temperature analysis.
5.4 Perform the temperature analysis.
5.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of temperature analyses.
5.6 Plan the laboratory control procedures for monitoring temperature.
5.7 Explain the theory behind the temperature analysis.

EQUIPMENT:

	ANALYSIS	SAMPLING
thermometer	x	

RESOURCES: 225 387 465 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 5.1: *Describe the sampling procedures for the temperature analysis.*

CONDITIONS:

Given *Standard Methods for the Examination of Water and Wastewater*, p. 348; *Method for Chemical Analysis of Water and Wastes*, p. 286; and these plant locations for grab samples:

influent
first stage digester
second stage digester

ACCEPTABLE PERFORMANCE:

The student will:

Name and describe the sampling equipment needed at each location.

Describe the best time and conditions for obtaining a representative reading from each location.

INSTRUCTOR ACTIVITY:

1. Describe the sampling equipment.
2. Describe the best conditions for obtaining a representative reading.
3. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. List and describe the sampling equipment.
2. Evaluate the conditions which guarantee that a representative reading is obtained.
3. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 5.2:

Perform the sampling procedures for the temperature analysis.

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE:

The student will:

Select and use the sample equipment.

Obtain a sample from each location.

INSTRUCTOR ACTIVITY:

1. Perform the sampling procedure.
2. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

3. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Select and use the sampling equipment, explaining his actions.
2. Demonstrate the sampling procedures in a dry run in the laboratory.
3. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 6.3: *Describe the method for temperature analysis.*

CONDITIONS: Given a standard reference.

ACCEPTABLE PERFORMANCE: The student will:

List the equipment needed to perform the analysis.

Describe the safety procedures for using a thermometer.

Explain how these safety precautions protect employees.

Describe the procedures for recording data.

Determine the temperature.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for using a thermometer.
3. Explain the procedures for recording data.
4. Check the flow chart which the student has prepared for the analysis.
5. Display the thermometer. Explain how to read the temperature.

STUDENT ACTIVITY:

1. Obtain a list of equipment for the analysis.
2. State the safety precautions followed when using a thermometer.
3. List the procedures for recording data.
4. Develop a flow chart for the analysis.
5. Practice reading the thermometer.

<<<<<<>>>>>>

OBJECTIVE 5.4: *Perform the temperature analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Obtain the equipment.

Perform the analysis on a sample from a plant location.

Record data, determine the temperature and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain the equipment for temperature analysis.
2. Perform the analysis on a sample.
3. Observe the student demonstrating the analysis in a dry run in the laboratory.
4. Observe the student performing the analysis in the laboratory.
5. Explain how to record data, determine the temperature and complete the report forms.

STUDENT ACTIVITY:

1. Obtain the equipment for temperature analysis.
2. Observe the instructor demonstrating the analysis.
3. Demonstrate the analysis in a dry run in the laboratory.
4. Perform the analysis.
5. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 5.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of temperature analyses.*

CONDITIONS: Given references and the results of temperature analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal temperature levels found in these unit processes:
  collection
  first stage digestion
  second stage digestion

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal temperature levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal temperature levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of the analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 5.6: *Plan the laboratory control procedures for monitoring temperature.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for temperature.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring temperature.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring temperature.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for temperature.
2. Describe sampling locations and the frequency and methods of analysis for monitoring temperature.
3. Discuss requirements for equipment, storage, records and reports for monitoring temperature.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for temperature.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring temperature.
3. Discuss requirements for equipment, storage, records and reports for monitoring temperature.
4. Work in small groups to plan the laboratory control procedures for monitoring temperature.

<<<<<<>>>>>>

OBJECTIVE 5.7: *Explain the theory behind the temperature analysis.*

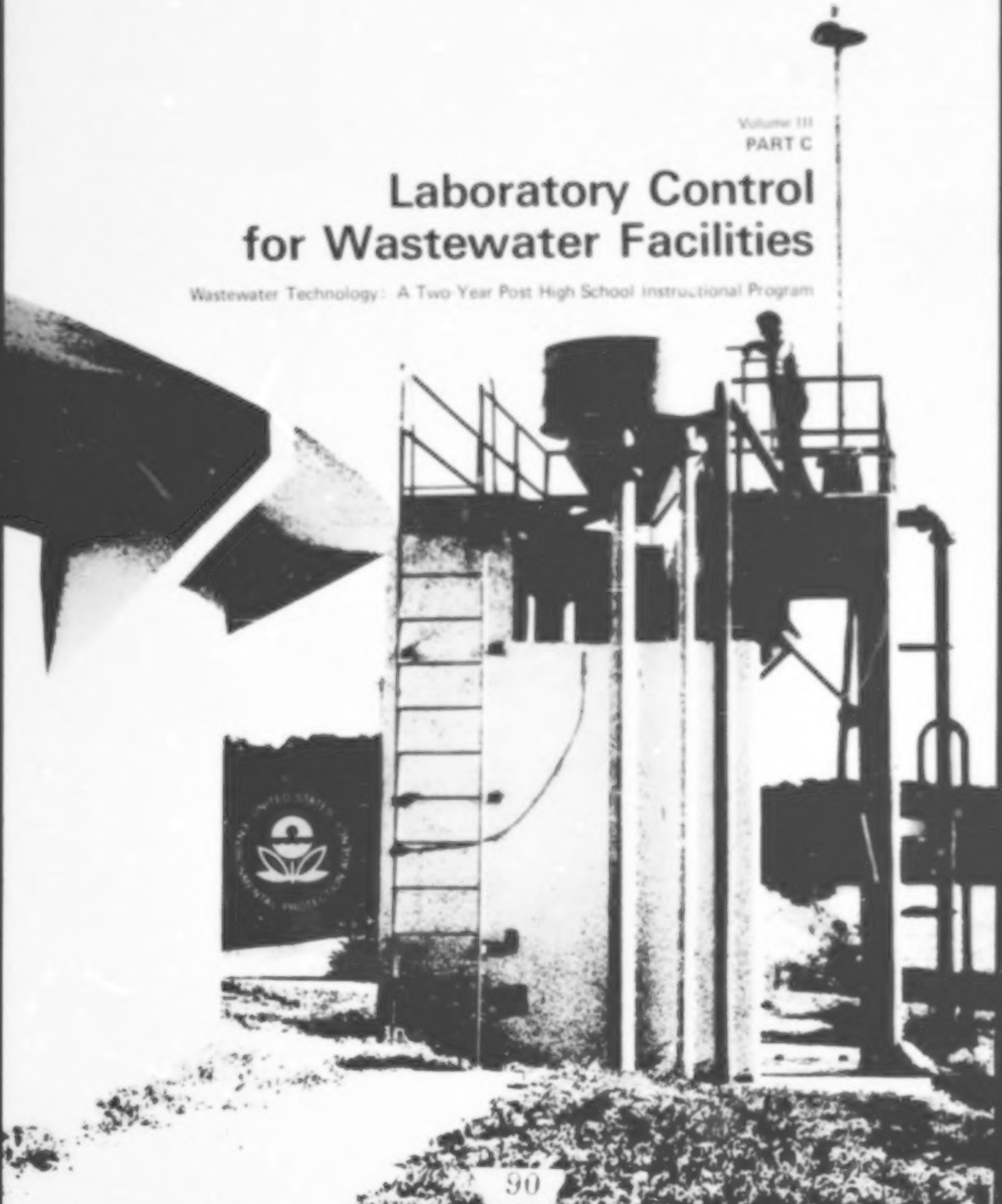
CONDITIONS:	Given personal notes.
ACCEPTABLE PERFORMANCE:	In technical and nontechnical terms the student will: Describe the role of temperature in the purification of natural waters and in wastewater treatment processes.
INSTRUCTOR ACTIVITY:	1. Discuss the role of temperature in the purification of natural waters and treatment of wastewater.
STUDENT ACTIVITY:	1. Describe the role of temperature in the purification of natural waters and treatment of wastewater.

<<<<<<>>>>>>

Volume III
PART C

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program



LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part C

Biochemical Oxygen Demand
Chemical Oxygen Demand
Chlorine Requirement
Dissolved Oxygen
Fecal Coliform
Total Residual Chlorine

An Instructor's Guide for Use of Instructional Material
In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systemr Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page

PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. . . . . Part A
Module B National Pollutant Discharge Elimination System. . . . . . . Part A
Module C Safety . . . . Part A
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . Part B
Module 3 Chloride . . . . Part B
Module 4 pH . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. 11
Module 7 Chemical Oxygen Demand 21
Module 8 Chlorine Requirement 31
Module 9 Dissolved Oxygen 41
Module 10 Fecal Coliform 53
Module 11 Total Residual Chlorine. 63
Module 12 Color. . . . . Part D
Module 13 Grease . . . . Part D
Module 14 Specific Conductance . . . . Part D
Module 15 Turbidity. . . . . Part D
Module 16 Ammonia Nitrogen . . . . Part E
Module 17 Kjeldahl Nitrogen. . . . . Part E
Module 18 Nitrate Nitrogen . . . . Part E
Module 19 Nitrite Nitrogen . . . . Part E
Module 20 Orthophosphate . . . . Part E
Module 21 Total Phosphorus . . . . Part E
Module 22 Settleable Matter. . . . . Part F
Module 23 Total Solids . . . . Part F
Module 24 Total Dissolved Solids . . . . Part F
Module 25 Total Suspended Solids . . . . Part F
Module 26 Total Volatile Solids. . . . . Part F
Module 27 Characteristics of Activated Sludge. . . . . Part G
Module 28 Sludge Conditioning. . . . . Part G
Module 29 Sludge Digester Gas. . . . . Part G

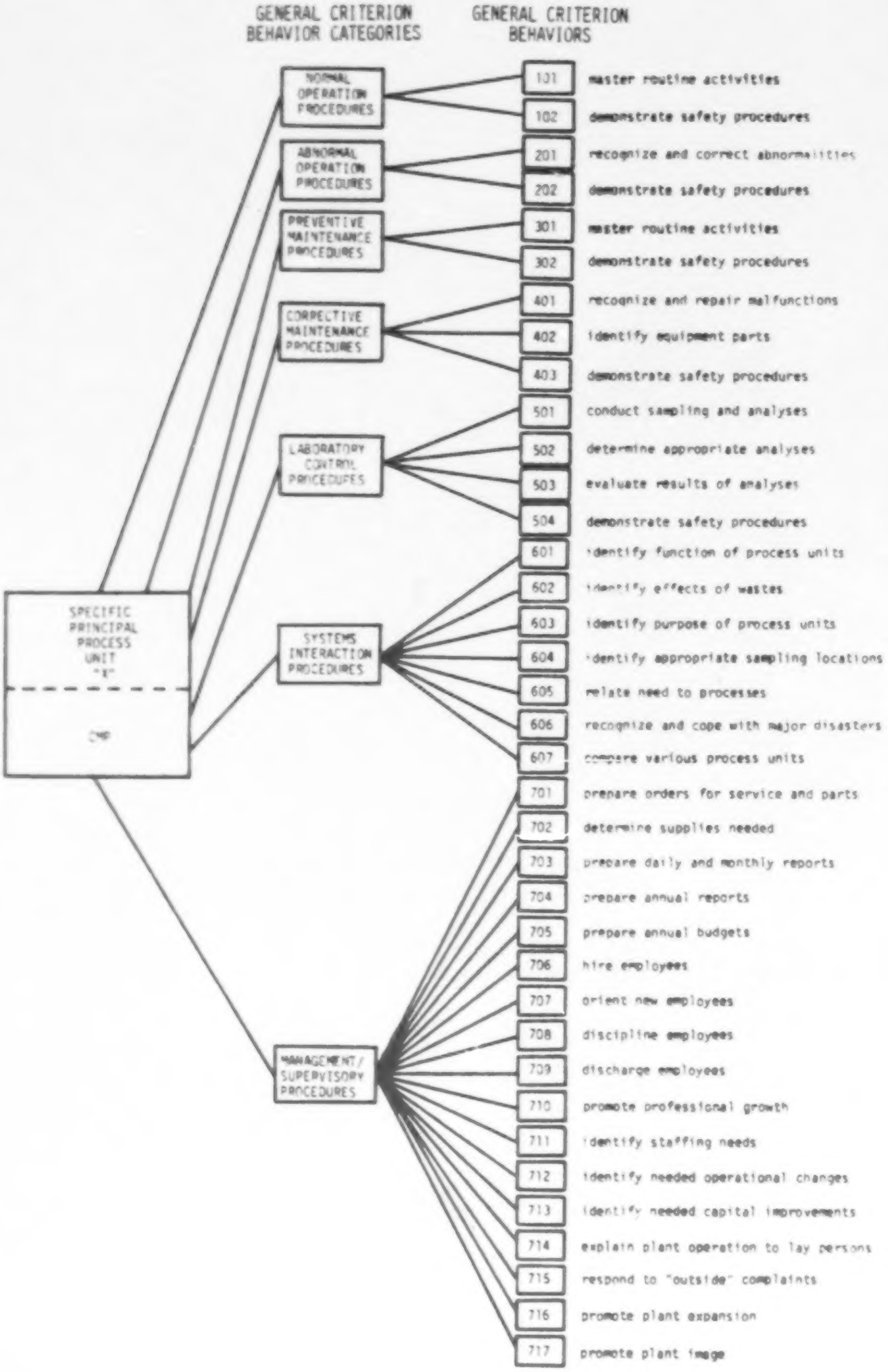

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
NORMAL OPERATION PROCEDURES
101 master routine activities
102 demonstrate safety procedures
ABNORMAL OPERATION PROCEDURES
201 recognize and correct abnormalities
202 demonstrate safety procedures
PREVENTIVE MAINTENANCE PROCEDURES
301 master routine activities
302 demonstrate safety procedures
CORRECTIVE MAINTENANCE PROCEDURES
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
LABORATORY CONTROL PROCEDURES
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
SYSTEMS INTERACTION PROCEDURES
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
MANAGEMENT/ SUPERVISORY PROCEDURES
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant.* If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 6

BIOCHEMICAL OXYGEN DEMAND

PURPOSE: *In this module the student will learn to determine the biochemical oxygen demand (BOD) of a sample of wastewater by using the modified Winkler method. This analysis measures the oxygen used by aerobic microorganisms in the wastestream and provides an indirect estimate of the concentration of organic solids. The BOD of an effluent can indicate failure of a treatment process and the need for adjustments in operation procedures. Limits are usually placed on the BOD allowed in an effluent. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A and module 9 on dissolved oxygen, page 41.*

OBJECTIVES:

6.1 Describe the sampling procedures for the BOD analysis.
6.2 Perform the sampling procedures for the BOD analysis.
6.3 Describe the modified Winkler method for BOD analysis.
6.4 Perform the BOD analysis.
6.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of BOD analyses.
6.6 Plan the laboratory control procedures for monitoring BOD.
6.7 Explain the theory behind the BOD analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
calcium chloride	x	
distilled water	x	
ferric chloride	x	
glucose or dextrose	x	
glutamic acid	x	
magnesium sulfate	x	
phosphate buffer solution	x	
sodium hydroxide, 1.0*N*	x	
sodium sulfite, anhydrous	x	
sulfuric acid, 1.0*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
BOD bottles with stoppers, 300 ml	x	x
buret caps	x	
buret clamps	x	
burets, 50 ml	x	
distillation apparatus	x	
drying oven	x	
Erlenmeyer flasks, 250 ml	x	
graduated cylinders, 100 ml	x	
incubator	x	
oxygen-sensitive membrane electrode and meter	x	
pH meter	x	
pipets, volumetric, 2 ml	x	
refrigerator		x
ring stands	x	
rubber bulbs	x	
rubber tubing	x	
volumetric flasks, 1 liter	x	
water bath	x	
water sample bottles with stoppers, 125 ml		x
water still	x	
weighing bottle	x	

RESOURCES: 49 50 51 142 225 387 465 587 588 833 852 866
1033 1034 1125 1326 1336 1348 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 6.1: *Describe the sampling procedures for the BOD analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 489* and these plant locations for grab and composite samples:
influent
chlorination effluent
screen and grinder effluent
grit chamber
primary sedimentation tank
trickling filter underdrain
aerator
secondary sedimentation tank
pond
thickener

first stage digester
second stage digester
sludge conditioner
sludge dewaterer
solids disposal sight
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.

6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 6.2: *Perform the sampling procedures for the BOD analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 6.3: *Describe the modified Winkler method for BOD analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating BOD and BOD data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for using incubators and for pipetting samples and reagents.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
- standardization
- initial titration
- incubation
- final titration

Describe the end points in the titration procedure.

Describe procedures for recording data.

Calculate the BOD.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for using incubators and for pipetting samples and reagents.
3. Describe the major steps in the BOD analysis and describe the color changes at the end points.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating BOD, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when using incubators and when pipetting samples and reagents.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 6.4: *Perform the BOD analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare the reagents.

Prepare the samples.

Incubate the samples prepared for final DO analysis.

Perform the initial dissolved oxygen (DO) analysis on a sample from a plant location.

Record data from the initial DO analysis.

Perform the analysis for final DO on the incubated samples after the incubation period has elapsed.

Record data, calculate the BOD and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the reagents.
3. Demonstrate how to prepare the sample for initial analysis and incubation.
4. Perform the analysis on a sample for initial DO and after incubation for final DO.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the BOD and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the reagents.
3. Prepare the sample for initial analysis and incubation.
4. Observe the instructor demonstrating the analysis for initial DO and after incubation for final DO.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 6.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of BOD analyses.*

CONDITIONS: Given references and the results of BOD analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal BOD levels found in these unit processes:
- collection
- chlorination
- screening and grinding
- grit removal
- primary sedimentation
- trickling filtration
- aeration
- secondary sedimentation
- pond stabilization
- thickening
- first stage digestion
- second stage digestion
- sludge conditioning
- sludge dewatering
- solids disposal
- effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
- increasing the frequency of testing
- sampling at different locations
- reporting to supervisors

Determine which of these factors causes a departure from normal levels:
- changes in the composition of the wastestream
- changes in treatment
- errors in sampling
- errors in laboratory technique
- errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal BOD levels.

2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal BOD levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 6.6: *Plan the laboratory control procedures for monitoring BOD.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for BOD.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring BOD.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring BOD.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for BOD.
2. Describe sampling locations and the frequency and methods of analysis for monitoring BOD.
3. Discuss requirements for equipment, storage, records and reports for monitoring BOD.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for BOD.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring BOD.
3. Discuss requirements for equipment, storage, records and reports for monitoring BOD.
4. Work in small groups to plan the laboratory control procedures for monitoring BOD.

<<<<<<>>>>>>

OBJECTIVE 6.7: *Explain the theory behind the BOD analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Describe the importance of the 5-day period of stabilization and why it is the accepted standard.

Discuss the purpose of incubating the samples at 20°C in the absence of light.

Discuss the purpose of seeding.

Explain how BOD results will be affected by:
- nitrification
- pH
- residual chlorine
- supersaturation
- temperature
- toxic materials

Discuss why the BOD analysis is considered a bioassay technique.

INSTRUCTOR ACTIVITY:

1. Explain the importance of the 5-day period of stabilization and why it is the accepted standard.

2. Explain the purpose of incubating the samples at 20°C in the absence of light.
3. Explain the purpose of seeding.
4. Explain the causes and effects of interferences.
5. Explain why the BOD analysis is considered a bioassay technique.

STUDENT ACTIVITY:

1. Describe the importance of the 5-day period of stabilization and why it is the accepted standard.
2. Discuss the purpose of incubating the samples at 20°C in the absence of light.
3. Discuss the purpose of seeding.
4. Discuss the interferences.
5. Discuss why the BOD analysis is considered a bioassay technique.

<<<<<<>>>>>>

Module 7

CHEMICAL OXYGEN DEMAND

PURPOSE: *In this module the student will learn to determine the chemical oxygen demand (COD) of a sample of wastewater by using the dichromate method. The chemical oxygen demand analysis is used with biochemical oxygen demand to estimate the pollutional strength of wastewater by measuring the dichromate needed to oxidize organic matter to carbon dioxide and water. Results can be obtained in a relatively short time and thus measures can be taken to adjust treatment processes within several hours. This test is particularly valuable in the analysis of combined sewage and industrial wastes, where the waste is not oxidized by biological action alone. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

7.1 Describe the sampling procedures for the COD analysis.
7.2 Perform the sampling procedures for the COD analysis.
7.3 Describe the dichromate method for COD analysis.
7.4 Perform the COD analysis.
7.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of COD analyses.
7.6 Plan the laboratory control procedures for monitoring COD.
7.7 Explain the theory behind the COD analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
distilled water	x	
ferroin indicator	x	
ferrous ammonium sulfate, 0.10*N*	x	
mercuric sulfate	x	
potassium dichromate, 0.250*N*	x	
silver sulfate	x	
sulfamic acid	x	
sulfuric acid	x	x

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
buret cap	x	
buret clamp	x	
buret, 50 ml	x	
condenser	x	
Erlenmeyer flask, 500 ml	x	
glass beads	x	
graduated cylinder, 100 ml	x	
pipets, volumetric, 10 and 20 ml	x	
refluxing flasks, 300 ml	x	
refrigerator		x
ring stand	x	
rubber tubing	x	
stirring rods	x	
volumetric flasks, 1 liter	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 539 557 833 866 1033 1034 1125 1326 1336 1370 1461 1473 1729

<<<<<<>>>>>>

OBJECTIVE 7.1: *Describe the sampling procedures for the COD analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 495; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 219; Method for Chemical Analysis of Water and Wastes, p. 17;* and these plant locations for composite samples:

- influent
- chlorination effluent
- screen and grinder effluent
- grit chamber
- primary sedimentation tank
- trickling filter underdrain
- aerator
- secondary sedimentation tank
- pond
- thickener
- first stage digester
- second stage digester
- sludge conditioner

sludge dewaterer
solids disposal sight
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers. List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation and the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 7.2: *Perform the sampling procedures for the COD analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 7.3: *Describe the dichromate method for COD analysis.*

CONDITIONS: Given a standard reference, the formula for calculating COD and COD data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing silver sulfate-sulfuric acid solution.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
refluxing
titration

Describe the end point in the titration procedure.

Describe the procedures for recording data.

Calculate the COD.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for working with silver sulfate-sulfuric acid solution and with sulfuric acid.
3. Describe the major steps in the COD analysis and describe the end point of the titration.
4. Explain the procedures for recording data.
5. Check the flow chart for the COD analysis which the student has prepared.
6. Present the formula for calculating COD, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing silver sulfate-sulfuric acid solution.
3. List the major steps in the analysis and describe the end point of the titration.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 7.4: *Perform the COD analysis.*

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE:

The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the COD and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the COD and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 7.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of COD analyses.

CONDITIONS:

Given references and the results of COD analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal COD levels found in these unit processes:

- collection
- chlorination
- screening and grinding
- grit removal
- primary sedimentation
- trickling filtration
- aeration
- secondary sedimentation
- pond stabilization
- thickening
- first stage digestion
- second stage digestion
- sludge conditioning
- sludge dewatering
- solids disposal
- effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:

- increasing the frequency of testing
- sampling at different locations
- reporting to supervisors

Determine which of these factors causes a departure from normal levels:

- changes in the composition of the wastestream
- changes in treatment
- errors in sampling
- errors in laboratory technique
- errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal COD levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.

4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal COD levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 7.6: *Plan the laboratory control procedures for monitoring COD.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for COD.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring COD.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring COD.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for COD.

2. Describe sampling locations and the frequency and methods of analysis for monitoring COD.
3. Discuss requirements for equipment, storage, records and reports for monitoring COD.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for COD.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring COD.
3. Discuss requirements for equipment, storage, records and reports for monitoring COD.
4. Work in small groups to plan the laboratory control procedures for monitoring COD.

<<<<<<>>>>>>

OBJECTIVE 7.7: *Explain the theory behind the COD analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of oxygen in the purification of natural waters.

Explain how COD results will be affected by:
aromatic hydrocarbon
chlorides
fatty acids
ferrous iron
nitrates
pyridine
sulfides

Explain why the dichromate method is most commonly used.

Describe the role of the indicator.

State the oxidation-reduction reaction equation, explaining the reactions taking place during the analysis. Name the substances being oxidized and reduced in this equation.

INSTRUCTOR ACTIVITY:

1. Explain how the oxidizing power of dissolved oxygen is used.
2. Explain the causes and effects of interferences.

3. Explain why the dichromate method is most commonly used.
4. Describe the role of the indicator.
5. Present the oxidation-reduction reaction equation, explaining the reactions taking place during the analysis. Name the oxidizing and reducing agents.

STUDENT ACTIVITY:

1. Explain how the oxidizing power of dissolved oxygen is used.
2. Discuss the interferences.
3. Explain why the dichromate method is most commonly used.
4. Explain the role of the indicator.
5. State the oxidation-reduction reaction equation, explaining the reactions taking place during the analysis. Name the oxidizing and reducing agents.

<<<<<<>>>>>>

Module 8

CHLORINE REQUIREMENT

PURPOSE: *In this module the student will learn to determine the chlorine requirement of a sample of wastewater by using the amperometric method. This analysis measures the chlorine which must be added to wastewater to produce the desired results. Chlorine may be added to reduce coliform density, to provide a specified residual chlorine concentration or to oxidize a chemical. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

8.1 Describe the sampling procedures for the chlorine requirement analysis.
8.2 Perform the sampling procedures for the chlorine requirement analysis.
8.3 Describe the amperometric method for chlorine requirement analysis.
8.4 Perform the chlorine requirement analysis.
8.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of chlorine requirement analyses.
8.6 Plan the laboratory control procedures for monitoring chlorine requirement.
8.7 Explain the theory behind the chlorine requirement analysis.

CHEMICALS	ANALYSIS	SAMPLING
acetate buffer solution	x	
acetic acid, glacial and concentrated	x	
arsenite, 0.1*N*	x	
chlorine gas	x	
chloroform	x	
distilled water	x	
hydrochloric acid, 6*N* and concentrated	x	
iodine, 0.1*N*, 0.0282*N* and 0.00564*N*	x	
phenylarsineoxide, 0.00564*N*	x	

CHEMICALS: *continued*

	ANALYSIS	SAMPLING
phosphoric acid	x	
potassium dichromate	x	
potassium iodate	x	
potassium iodide	x	
sodium acetate	x	
sodium hydroxide, 0.3*N*	x	
sodium sulfite	x	
sodium thiosulfate	x	
starch indicator	x	
sulfuric acid	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250, 400 and 600 ml	x	
bottle, dark, 250 ml	x	
buret caps	x	
buret clamps	x	
burets, 5 and 25 ml	x	
Erlenmeyer flasks, 50 ml	x	
graduated cylinders, 10, 25, 100 and 250 ml	x	
hot plate	x	
pH meter	x	
pipets, measuring, 2 and 5 ml	x	
pipets, volumetric, 5 and 10 ml	x	
refrigerator		x
ring stands	x	
stirring rods	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES:

48 142 225 387 465 472 489 556 590 700 702 787
833 866 1033 1034 1078 1079 1125 1326 1336 1370 1461 1473
1513

<<<<<<>>>>>>

OBJECTIVE 8.1: *Describe the sampling procedures for the chlorine requirement analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 388; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 761; Method for Chemical*

Analysis of Water and Wastes, p. 36; and these plant locations for grab samples:

  chlorination influent
  chlorination effluent

ACCEPTABLE PERFORMANCE:

The student will:

Describe the routine preparation of sample containers. List this information to appear on each container:

  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 8.2:

Perform the sampling procedures for the chlorine requirement analysis.

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 8.3: *Describe the amperometric method for chlorine requirement analysis.*

CONDITIONS: Given a standard reference, the formula for calculating chlorine requirement and chlorine requirement data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for standardizing phenylarsine oxide, handling acids and bases, preparing standard arsenite solution, handling chlorine gas and preparing culture dishes.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
- standardization
- titration
- preparation of culture dishes
- incubation
- plate count

Describe the end point in the titration procedure.

Describe the identification of colonies.

Describe the procedures for recording data.

Calculate the chlorine requirement.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for standardizing phenylarsine oxide, handling acids and bases, preparing standard arsenite solution, handling chlorine gas and preparing culture dishes.
3. Describe the major steps in the chlorine requirement analysis and describe the color change at the end point.
4. Describe the procedure for identifying colonies.
5. Explain the procedures for recording data.
6. Check the flow chart for the analysis which the student has prepared.
7. Present the formula for calculating chlorine requirement, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when standardizing phenylarsine oxide, handling acids and bases, preparing standard arsenite solution, handling chlorine gas and preparing culture dishes.
3. List the major steps in the analysis and describe the color change at the end point.
4. Describe the procedure for identifying colonies.
5. List the procedures for recording data.

6. Develop a flow chart for the analysis.
7. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 8.4: *Perform the chlorine requirement analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the chlorine requirement and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the chlorine requirement and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 8.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of chlorine requirement analyses.*

CONDITIONS: Given references and the results of chlorine requirement analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal chlorine requirement levels found in this unit process:
  chlorination

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal chlorine requirement levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal chlorine requirement levels for the unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 8.6: *Plan the laboratory control procedures for monitoring chlorine requirement.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for chlorine requirement.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring chlorine requirement.

Determine requirements for:
library
records and reports
storage for equipment and supplies
support equipment
test equipment

Prepare laboratory control reports and procedures for monitoring chlorine requirement.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for chlorine requirement.
2. Describe sampling locations and the frequency and methods of analysis for monitoring chlorine requirement.
3. Discuss requirements for equipment, storage, records and reports for monitoring chlorine requirement.

4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for chlorine requirement.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring chlorine requirement.
3. Discuss requirements for equipment, storage, records and reports for monitoring chlorine requirement.
4. Work in small groups to plan the laboratory control procedures for monitoring chlorine requirement.

<<<<<<>>>>>>

OBJECTIVE 8.7: *Explain the theory behind the chlorine requirement analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of chlorine in the purification of natural waters.

Explain how chlorine requirement results will be affected by:
contact time
pH
temperature

State the chemical equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain the role of chlorine in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Present the chemical equations, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Discuss the role of chlorine in the purification of natural waters.
2. Discuss the interferences.
3. State the chemical equations, explaining the reactions taking place during analysis.

<<<<<<>>>>>>

Module 9

DISSOLVED OXYGEN

PURPOSE: *In this module the student will learn to determine the dissolved oxygen (DO) in a sample of wastewater by using the modified Winkler method and the probe method. In the modified Winkler method oxidized manganese liberates iodine which is equivalent to the DO content of the sample. The probe method is based on the rate of diffusion of molecular oxygen across a membrane. Results of the analysis are used to monitor the effects of effluent discharges on the available oxygen resources of receiving water. The analysis is an integral part of the biochemical oxygen demand test. The dissolved oxygen content of the wastestream affects the operation of such aerobic treatment processes as trickling filtration, activated sludge, extended aeration and contact stabilization. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

9.1 Describe the sampling procedures for the DO analysis.
9.2 Perform the sampling procedures for the DO analysis.
9.3 Describe the modified Winkler and the probe methods for DO analysis.
9.4 Perform the DO analysis.
9.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of DO analyses.
9.6 Plan the laboratory control procedures for monitoring DO.
9.7 Explain the theory behind the DO analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
alkali-iodide-azide	x	
chloroform	x	
distilled water	x	
manganous sulfate	x	
potassium bioiodate, 0.025*N*	x	
potassium dichromate, 0.025*N*	x	
potassium fluoride	x	

CHEMICALS: *continued*

	ANALYSIS	SAMPLING
sodium thiosulfate, 0.025*N* and 0.10*N*	x	
starch solution	x	
sulfuric acid, concentrated	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
BOD bottles with stoppers, 300 ml	x	x
buret, 50 ml	x	
buret cap	x	
buret clamp	x	
buret support	x	
Erlenmeyer flasks, 500 ml	x	
graduated cylinders, 10 and 250 ml	x	
hot plate	x	
pipets, measuring, 2 ml	x	
pipets, volumetric, 20 ml	x	
rubber bulbs	x	
rubber tubing		x
stirring rods	x	
thermometer		x
volumetric flasks, 1 liter	x	
wash bottle	x	
water sample bottles with stoppers, 125 ml		x
water still	x	

RESOURCES: 142 225 387 465 488 540 585 709 833 866 1024 1033
1034 1125 1326 1336 1370 1413 1461 1473 1765 1834

<<<<<<>>>>>>

OBJECTIVE 9.1: *Describe the sampling procedures for the DO analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 474, p. 484; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 372, p. 376; Method for Chemical Analysis of Water and Wastes, p. 53, p. 60;* and these plant locations for grab samples:

- influent
- trickling filter underdrain
- aerator
- secondary sedimentation tank
- pond

first stage digester
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation and the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 9.2: *Perform the sampling procedures for the DO analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 9.3a: *Describe the modified Winkler method for DO analysis.*

CONDITIONS: Given a standard reference, the formula for calculating DO and DO data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing alkali-iodide-azide reagent and pipetting concentrated sulfuric acid and other chemicals.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
standardization
titration

Describe the end point in the titration procedure.

Describe the procedures for recording data.

Calculate the DO.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for preparing alkali-iodide-azide reagent and pipetting sulfuric acid and other chemicals.
3. Describe the major steps in the DO analysis and describe the end point of the titration.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating DO, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing alkali-iodide-azide reagent and pipetting sulfuric acid and other chemicals.
3. List the major steps in the analysis and describe the color change at the end point of the titration.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 9.3b: *Describe the probe method for DO analysis.*

CONDITIONS: Given a standard reference.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of equipment needed to perform the analysis.

Describe the safety procedures for using a DO meter.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  calibration
  sample measurement

Describe the procedure for sample measurement with the probe.

Describe the procedures for recording data.

Practice reading the DO meter.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for using the DO meter.
3. Describe the steps necessary to perform a DO analysis and describe the proper procedure for sample measurement with the probe.
4. Explain the procedures for recording data.
5. Check the flow chart which the student has prepared for the analysis.
6. Explain how to read the DO meter.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when using the DO meter.
3. List the steps necessary to perform a DO analysis and describe the proper procedure for sample measurement with the probe.
4. List the procedures for recording data.
5. Develop a flow chart for the probe method of DO analysis.
6. Practice reading the DO meter.

<<<<<<>>>>>>

OBJECTIVE 9.4a: *Perform the dissolved oxygen analysis on a sample using the modified Winkler method.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the DO and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the DO and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 9.4b: *Perform the dissolved oxygen analysis on a sample using the probe method.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE:

The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the DO and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the DO and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 9.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of DO analyses.

CONDITIONS:

Given references and the results of DO analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal DO levels found in these unit processes:
  collection
  trickling filtration
  aeration

  - secondary sedimentation
  - pond stabilization
  - first stage digestion
  - effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  - increasing the frequency of testing
  - sampling at different locations
  - reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  - changes in the composition of the wastestream
  - changes in treatment
  - errors in sampling
  - errors in laboratory technique
  - errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal DO levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal DO levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.

5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 9.6: *Plan the laboratory control procedures for monitoring DO.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for DO.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring DO.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring DO.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for DO.
2. Describe sampling locations and the frequency and methods of analysis for monitoring DO.
3. Discuss requirements for equipment, storage, records and reports for monitoring DO.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for DO.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring DO.
3. Discuss requirements for equipment, storage, records and reports for monitoring DO.
4. Work in small groups to plan the laboratory control procedures for monitoring DO.

<<<<<<>>>>>>

OBJECTIVE 9.7: *Explain the theory behind the DO analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of DO in the purification of natural waters.

Explain how DO results will be affected by:
- ferric salts
- highly colored waters
- nitrites
- organic compounds
- oxidizing agents
- reducing agents
- suspended solids

Explain why the azide modification of the Winkler method is used for most wastewater, effluents and stream samples.

State the chemical equations, explaining the oxidation-reduction reactions.

INSTRUCTOR ACTIVITY:

1. Explain the role of DO in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Explain why the azide modification of the Winkler method is used for most wastewater, effluents and stream samples.
4. Present the equations, explaining the oxidation-reduction reactions.

STUDENT ACTIVITY:

1. Explain the role of DO in the purification of natural waters.
2. Discuss the interferences,
3. Explain why the azide modification of the Winkler method is used for most wastewater, effluents and stream samples.
4. State the equations, explaining the oxidation-reduction reactions.

<<<<<<>>>>>>

Module 10

FECAL COLIFORM

PURPOSE: *In this module the student will learn to determine the fecal-coliform bacterial density in a sample of wastewater by using the membrane filter method. In this analysis colonies of fecal-coliform bacteria are counted after incubation of membrane filter cultures. Results of the analysis indicate how much domestic wastewater has contaminated a water source and how much treatment is needed. The analysis is used in place of the tests for disease-causing organisms which are difficult to perform. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

10.1 Describe the sampling procedures for the fecal coliform analysis.
10.2 Perform the sampling procedures for the fecal coliform analysis.
10.3 Describe the membrane filter method for fecal coliform analysis.
10.4 Perform the fecal coliform analysis.
10.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of fecal coliform analyses.
10.6 Plan the laboratory control procedures for monitoring fecal coliform.
10.7 Explain the theory behind the fecal coliform analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
M-FC medium	x	
phosphate buffer solution, pH 7.2	x	
rosolic acid	x	
sodium hydroxide, 0.2*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
aspirator	x	
balance	x	
bottles, 160 ml	x	
burner	x	
dishes, sterile, 60 x 15 mm	x	
distillation apparatus	x	
drying oven	x	
filter flasks, 1000 ml	x	
filter holder	x	
flasks, screw cap, 125 and 500 ml	x	
forceps	x	
graduated cylinders, 100 and 500 ml	x	
hot plate	x	
illuminator, fluorescent	x	
incubator	x	
microscope	x	
pipets, volumetric, 2 ml	x	
refrigerator	x	x
rubber stoppers, 2 hole	x	
rubber tubing	x	
spatula	x	
steroclave or sterilizer	x	
thermometer	x	
water bath	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES:

225 387 426 437 465 574 589 833 866 1014 1033 1034
1125 1325 1326 1336 1352 1364 1370 1414 1415 1461 1473 1620
1621 1626 1628 1629 1833

<<<<<<>>>>>>

OBJECTIVE 10.1: *Describe the sampling procedures for the fecal coliform analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 684* and this plant location for grab samples:
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
date

place
time
name of person who collected the sample

Name and describe the sampling equipment.

Explain conditions to avoid while sampling and transporting the sample.

Describe the best time and conditions for obtaining a representative sample.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 10.2: *Perform the sampling procedures for the fecal coliform analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 10.3: *Describe the membrane filter method for fecal coliform analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating fecal coliform and fecal coliform data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing culture dishes and sterilizing membrane filter holders.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  preparation of culture dishes
  incubation
  plate count

Describe the identification of colonies.

Describe the procedures for recording data.

Calculate the fecal coliform concentration.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for preparing culture dishes and sterilizing membrane filter holders.
3. Describe the major steps in the analysis.
4. Describe the procedures for identifying colonies.
5. Explain the procedures for recording data.
6. Check the flow chart for the analysis which the student has prepared.
7. Present the formulas for calculating fecal coliform concentration, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing culture dishes and sterilizing membrane filter holders.
3. List the major steps in the analysis.
4. Describe the procedures for identifying colonies.
5. List the procedures for recording data.
6. Develop a flow chart for the analysis.
7. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 10.4: *Perform the fecal coliform analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the fecal coliform concentration and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the fecal coliform concentration and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 10.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of fecal coliform analyses.*

CONDITIONS: Given references and the results of fecal coliform analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal fecal coliform levels found in this unit process:
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment

errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal fecal coliform levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal fecal coliform levels for the unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 10.6: *Plan the laboratory control procedures for monitoring fecal coliform.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for fecal coliform.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring fecal coliform.

Determine requirements for:
library
records and reports
storage for equipment and supplies
support equipment
test equipment

Prepare laboratory control reports and precedures for monitoring fecal coliform.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for fecal coliform.
2. Describe sampling locations and the frequency and methods of analysis for monitoring fecal coliform.
3. Discuss requirements for equipment, storage, records and reports for monitoring fecal coliform.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for fecal coliform.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring fecal coliform.
3. Discuss requirements for equipment, storage, records and reports for monitoring fecal coliform.
4. Work in small groups to plan the laboratory control procedures for monitoring fecal coliform.

OBJECTIVE 10.7: *Explain the theory behind the fecal coliform analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of fecal coliform analysis in environmental control.

Explain how fecal coliform results will be affected by:
incubation temperature
noncoliform bacteria
turbidity

Explain why the membrane filter method of analysis of fecal coliform is most commonly used.

INSTRUCTOR ACTIVITY:

1. Explain the role of fecal coliform analysis in environmental control.
2. Explain the causes and effects of interferences.
3. Explain why the membrane filter method for analysis of fecal coliform is most commonly used.

STUDENT ACTIVITY:

1. Explain the role of fecal coliform analysis in environmental control.
2. Discuss the interferences.
3. Explain why the membrane filter method for analysis of fecal coliform is most commonly used.

<<<<<<>>>>>>

Module 11

TOTAL RESIDUAL CHLORINE

PURPOSE: *In this module the student will learn to determine the total residual chlorine of a sample of wastewater by using the amperiometric method. This analysis measures the chlorine left in the wastestream after the added chlorine has reacted with the wastewater. Results of the analysis are used to insure effective disinfection without waste of chlorine and to determine whether an effluent is suitable for discharge. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

11.1 Describe the sampling procedures for the total residual chlorine analysis.
11.2 Perform the sampling procedures for the total residual chlorine analysis.
11.3 Describe the amperiometric method for total resisual chlorine analysis.
11.4 Perform the total residual chlorine analysis.
11.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total residual chlorine analyses.
11.6 Plan the laboratory control procedures for monitoring total residual chlorine.
11.7 Explain the theory behind the total residual chlorine analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
acetate buffer solution	x	
chloroform	x	
distilled water	x	
hydrochloric acid, 6*N* and concentrated	x	
iodate, 0.00564*N*	x	
iodine, 0.1*N* and 0.0282*N*	x	
phenylarsine oxide, 0.00564*N*	x	
potassium iodide	x	
sodium arsenite, 0.10*N*	x	

CHEMICALS: *continued*

	ANALYSIS	SAMPLING
sodium hydroxide, 0.3*N*	x	
sodium thiosulfate, 0.1*N* and 0.00564*N*	x	
starch indicator	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
bottles, dark, 250 ml	x	
buret caps	x	
buret clamps	x	
burets, 50 ml	x	
drying oven	x	
Erlenmeyer flasks, 250 ml	x	
graduated cylinders, 100 ml	x	
pH meter	x	
pipets, measuring, 10 ml	x	
refrigerator		x
ring stands	x	
rubber bulbs	x	
volumetric flasks, 1 liter	x	
wash bottle	x	
water still	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES:

142 225 387 465 472 488 489 556 576 700 702 833
866 1033 1034 1078 1079 1125 1326 1336 1370 1461 1473 1513
1787

<<<<<<>>>>>>

OBJECTIVE 11.1: *Describe the sampling procedures for the total residual chlorine analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 382; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 223;* and these plant locations for grab samples:

chlorination influent
chlorination effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.

List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 11.2: *Perform the sampling procedures for the total residual chlorine analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 11.3: *Describe the amperiometric method for total residual chlorine analysis.*

CONDITIONS: Given a standard reference, the formula for calculating total residual chlorine and total residual chlorine data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for standardizing phenylarsine oxide solution, handling acids and bases and preparing standard arsenite solution.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  standardization
  titration

Describe the end point in the titration procedure.

Describe the procedures for recording data.

Calculate the total residual chlorine.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for standardizing phenylarsine oxide solution, handling acids and bases and preparing standard arsenite solution.
3. Describe the major steps in the total residual chlorine analysis and describe the end point of the titration.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total residual chlorine, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when standardizing phenylarsine oxide solution, handling acids and bases and preparing standard arsenite solution.
3. List the major steps in the analysis and describe the end point of titration.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 11.4: *Perform the total residual chlorine analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total residual chlorine and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the total residual chlorine and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 11.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total residual chlorine analyses.*

CONDITIONS: Given references and the results of total residual chlorine analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal total residual chlorine levels found in these unit processes:
  chlorination

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:

changes in the composition of the wastestream
changes in treatment
errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal total residual chlorine levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal total residual chlorine levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 11.6: *Plan the laboratory control procedures for monitoring total residual chlorine.*

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for total residual chlorine.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total residual chlorine.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring total residual chlorine.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total residual chlorine.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total residual chlorine.
3. Discuss requirements for equipment, storage, records and reports for monitoring total residual chlorine.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total residual chlorine.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total residual chlorine.
3. Discuss requirements for equipment, storage, records and reports for monitoring total residual chlorine.
4. Work in small groups to plan the laboratory control procedures for monitoring total residual chlorine.

<<<<<<>>>>>>

OBJECTIVE 11.7:

Explain the theory behind the total residual chlorine analysis.

CONDITIONS:

Given personal notes.

ACCEPTABLE PERFORMANCE:

In technical and nontechnical terms the student will:

Discuss the role of total residual chlorine analysis in the purification of natural waters.

Explain how total residual chlorine results will be affected by:

- color
- contact time
- ferric compounds
- manganic compounds
- nitrite compounds
- pH
- residual chlorine
- turbidity

State the chemical equations, explaining the reactions taking place during the analysis.

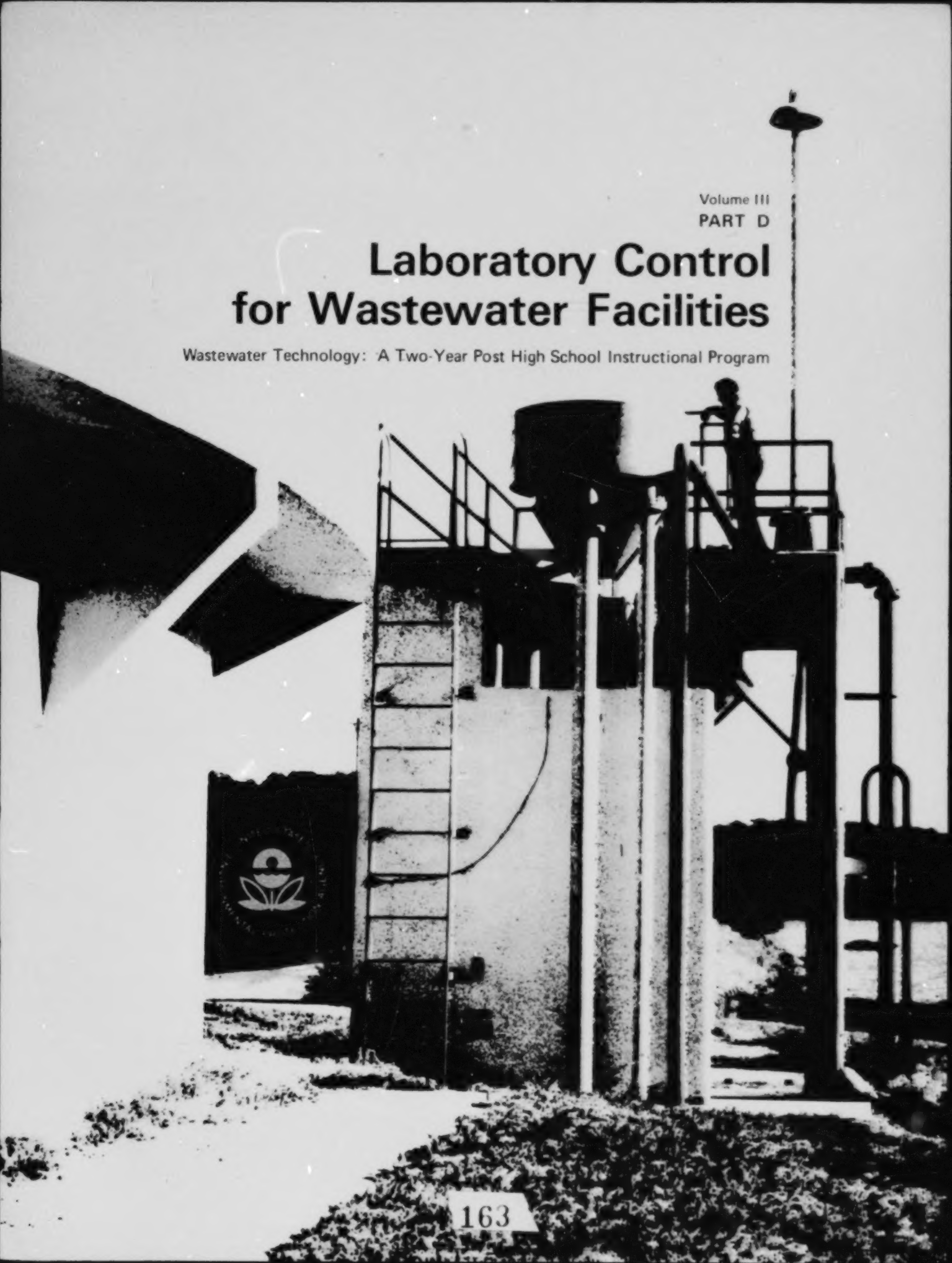
INSTRUCTOR ACTIVITY:

1. Explain the role of total residual chlorine analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Present the chemical equations, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Discuss the role of total residual chlorine analysis in the purification of natural waters.
2. Discuss the interferences.
3. State the chemical equations, explaining the reactions taking place during the analysis.

<<<<<<>>>>>>



Volume III

PART D

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program

LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part D

Color
Grease
Specific Conductance
Turbidity

An Instructor's Guide for Use of Instructional Material In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page
PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. . . . . Part A
Module B National Pollutant Discharge Elimination System. . . . . . . Part A
Module C Safety . . . . Part A
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . Part B
Module 3 Chloride . . . . Part B
Module 4 pH . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. . . . . Part C
Module 7 Chemical Oxygen Demand . . . . Part C
Module 8 Chlorine Requirement . . . . Part C
Module 9 Dissolved Oxygen . . . . Part C
Module 10 Fecal Coliform . . . . Part C
Module 11 Total Residual Chlorine. . . . . Part C
Module 12 Color. 11
Module 13 Grease 19
Module 14 Specific Conductance 27
Module 15 Turbidity. 37
Module 16 Ammonia Nitrogen . . . . Part E
Module 17 Kjeldahl Nitrogen. . . . . Part E
Module 18 Nitrate Nitrogen . . . . Part E
Module 19 Nitrite Nitrogen . . . . Part E
Module 20 Orthophosphate . . . . Part E
Module 21 Total Phosphorus . . . . Part E
Module 22 Settleable Matter. . . . . Part F
Module 23 Total Solids . . . . Part F
Module 24 Total Dissolved Solids . . . . Part F
Module 25 Total Suspended Solids . . . . Part F
Module 26 Total Volatile Solids. Part F
Module 27 Characteristics of Activated Sludge. . . . . Part G
Module 28 Sludge Conditioning. . . . . Part G
Module 29 Sludge Digester Gas. . . . . Part G

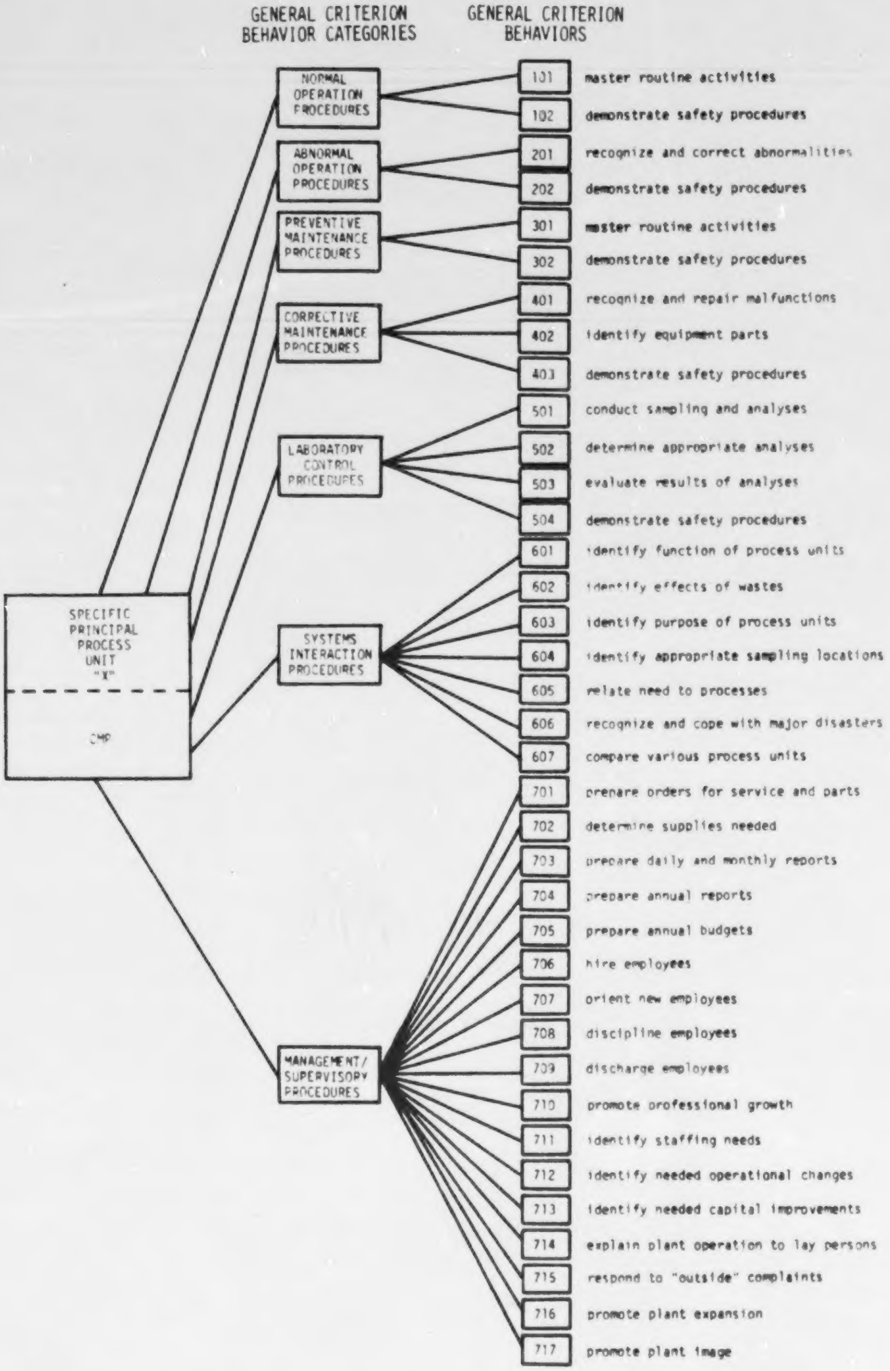

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
NORMAL OPERATION PROCEDURES
ABNORMAL OPERATION PROCEDURES
PREVENTIVE MAINTENANCE PROCEDURES
CORRECTIVE MAINTENANCE PROCEDURES
LABORATORY CONTROL PROCEDURES
SYSTEMS INTERACTION PROCEDURES
MANAGEMENT/ SUPERVISORY PROCEDURES
101 master routine activities
102 demonstrate safety procedures
201 recognize and correct abnormalities
202 demonstrate safety procedures
301 master routine activities
302 demonstrate safety procedures
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. **Corrective Maintenance Procedures.** These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. **Laboratory Control Procedures.** These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. **Systems Interaction Procedures.** These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. **Management/Supervisory Procedures.** These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant.* If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 12

COLOR

PURPOSE: *In this module the student will determine the color of a sample of wastewater by using the colorimetric method. This analysis measures color by visual comparison of the sample with standards of known concentration. Because consumers judge water quality by the color of the water and because the color of water may indicate the presence of harmful substances, color is removed from water supplies. Color analysis of wastewater and treated effluents insures efficient operation and produces effluents with a color value within the accepted limits. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A and module 4 on pH, page 43 of PART B.*

OBJECTIVES:

12.1 Describe the sampling procedures for the color analysis.
12.2 Perform the sampling procedures for the color analysis.
12.3 Describe the colorimetric method for color analysis.
12.4 Perform the color analysis.
12.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of color analyses.
12.6 Plan the laboratory control procedures for monitoring color.
12.7 Explain the theory behind the color analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
cobaltous chloride hexahydrate	x	
distilled water	x	
hydrochloric acid	x	
potassium chloroplatinate	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
centrifuge	x	
colorimeter (for field use)	x	
Nessler tubes	x	
pH meter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 833 866 1033 1034 1078 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 12.1: *Describe the sampling procedures for the color analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 160; Method for Chemical Analysis of Water and Wastes, p. 38;* and these plant locations for grab and composite samples:
- influent
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.

3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 12.2: *Perform the sampling procedures for the color analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 12.3: *Describe the colorimetric method for color analysis.*

CONDITIONS: Given a standard reference, the formula for calculating color and color data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for handling acids and bases and preparing standard solutions.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
- preparation of standards
- removal of turbidity
- estimation of color

Describe the procedures for recording data.

Calculate the color.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for handling acids and bases and preparing standard solutions.
3. Describe the major steps in the color analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating color, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.

2. State the safety precautions followed when handling acids and bases and preparing standard solutions.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 12.4: *Perform the color analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the color and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the color and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 12.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of color analyses.*

CONDITIONS: Given references and the results of color analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal color levels found in these unit processes:
  collection
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal color levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal color levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 12.6:

Plan the laboratory control procedures for monitoring color.

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for color.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring color.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring color.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for color.
2. Describe sampling locations and the frequency and methods of analysis for monitoring color.
3. Discuss requirements for equipment, storage, records and reports for monitoring color.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for color.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring color.
3. Discuss requirements for equipment, storage, records and reports for monitoring color.
4. Work in small groups to plan the laboratory control procedures for monitoring color.

<<<<<<>>>>>>

OBJECTIVE 12.7: *Explain the theory behind the color analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of color analysis in environmental control.

Explain how color results will be affected by:
  cobalt chloride in prepared standards
  pH
  suspended matter
  turbidity

State the difference between true color and apparent color.

INSTRUCTOR ACTIVITY:

1. Explain the role of color analysis in environmental control.
2. Explain the causes and effects of interferences.
3. Explain the difference between true color and apparent color.

STUDENT ACTIVITY:

1. Discuss the role of color analysis in environmental control.
2. Discuss the interferences.
3. Discuss the difference between true color and apparent color.

<<<<<<>>>>>>

Module 13

GREASE

PURPOSE: *In this module the student will learn to determine how much grease is in a sample of wastewater. In this analysis grease is extracted from the wastestream with an organic solvent. Grease deters oxygen transfer and accumulates in aeration equipment. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

13.1 Describe the sampling procedures for the grease analysis.
13.2 Perform the sampling procedures for the grease analysis.
13.3 Describe the method for grease analysis.
13.4 Perform the grease analysis.
13.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of grease analyses.
13.6 Plan the laboratory control procedures for monitoring grease.
13.7 Explain the theory behind the grease analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
sulfuric acid (1 + 1)		x
1,1,2-trichloro-1,2,2-trifluoroethane	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
condenser, 300 mm	x	
condenser clamps	x	
desiccator	x	
distillation flask, 250 ml	x	
drying oven	x	
Erlenmeyer flasks, 250 ml	x	
filter paper	x	
funnel	x	
graduated cylinders, 100 ml	x	

EQUIPMENT:
continued

	ANALYSIS	SAMPLING
hot plate	x	
ring stand	x	
rubber tubing	x	
separatory funnel, 500 ml	x	
steam bath	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 601 602 833 866 901 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 13.1: *Describe the sampling procedures for the grease analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 254* and these plant locations for grab and composite samples:

- influent
- grit chamber
- primary sedimentation tank
- first stage digester
- second stage digester

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation and the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.

2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 13.2: *Perform the sampling procedures for the grease analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.

4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 13.3: *Describe the method for grease analysis.*

CONDITIONS: Given a standard reference, the formula for calculating grease content and grease content data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for handling trichlorofluorethane, working with sulfuric acid and distilling solvent extract.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  extraction with organic solvent
  distillation

Describe the procedures for recording data.

Calculate the grease content.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for handling trichlorofluorethane, working with sulfuric acid and distilling solvent extract.

3. Describe the major steps in the grease analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating grease content, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when handling trichlorofluorethane, working with sulfuric acid and distilling solvent extract.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 13.4: *Perform the grease analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the grease content and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the grease content and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 13.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of grease analyses.

CONDITIONS:

Given references and the results of grease analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal grease levels found in these unit processes:
- collection
- grit removal
- primary sedimentation
- first stage digestion
- second stage digestion

Describe what to do if the results of the analyses are not within the normal range, including:
- increasing the frequency of testing
- sampling at different locations
- reporting to supervisors

Determine which of these factors causes a departure from normal levels:
- changes in the composition of the wastestream
- changes in treatment
- errors in sampling
- errors in laboratory technique
- errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

Discuss the reference materials used to determine normal grease levels.

2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal grease levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 13.6: *Plan the laboratory control procedures for monitoring grease.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for grease.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring grease.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring grease.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for grease.
2. Describe sampling locations and the frequency and methods of analysis for monitoring grease.
3. Discuss requirements for equipment, storage, records and reports for monitoring grease.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for grease.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring grease.
3. Discuss requirements for equipment, storage, records and reports for monitoring grease.
4. Work in small groups to plan the laboratory control procedures for monitoring grease.

<<<<<<>>>>>>

OBJECTIVE 13.7: *Explain the theory behind the grease analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of grease analysis in environmental control.

Explain how grease results will be affected by:
pH
solvent vapors
temperature

INSTRUCTOR ACTIVITY:

1. Explain the role of grease analysis in environmental control.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of grease analysis in environmental control.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 14

SPECIFIC CONDUCTANCE

PURPOSE: *In this module the student will learn to determine the specific conductance of a sample of wastewater by using the Wheatstone bridge method. This analysis measures the wastestream's capacity to carry an electric current. Results indicate the quantity of dissolved inorganic material. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

14.1 Describe the sampling procedures for the specific conductance analysis.
14.2 Perform the sampling procedures for the specific conductance analysis.
14.3 Describe the Wheatstone bridge method for specific conductance analysis.
14.4 Perform the specific conductance analysis.
14.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of specific conductance analyses.
14.6 Plan the laboratory control procedures for monitoring specific conductance.
14.7 Explain the theory behind the specific conductance analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
potassium chloride, 0.01*M*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
ring stand	x	
source of electrical current (null indicator or electron-ray "magic eye" tube)	x	
specific conductance cell	x	

EQUIPMENT: *continued*

	ANALYSIS	SAMPLING
test tubes	x	
thermometer	x	
water bath	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	
Wheatstone bridge	x	

RESOURCES: 225 387 465 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 14.1: *Describe the sampling procedures for the specific conductance analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 323; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 163; Method for Chemical Analysis of Water and Wastes, p. 284;* and this plant location for grab samples:
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment.

Explain conditions to avoid while sampling and transporting the sample.

Describe the best time and conditions for obtaining a representative sample.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample.

4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 14.2: *Perform the sampling procedures for the specific conductance analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.

2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 14.3: *Describe the Wheatstone bridge method for specific conductance analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating specific conductance and specific conductance data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for working with electrical equipment. Explain the procedures for the care and use of the conductivity cell.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  determine cell constant
  determine specific conductivity

Describe the procedures for recording data.

Calculate the specific conductance.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures used when working with electricity and when caring for and using the conductivity cell.
3. Describe the major steps in the specific conductance analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating specific conductance, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when working with electricity and when caring for and using the conductivity cell.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 14.4: *Perform the specific conductance analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the specific conductance and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepere the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the specific conductance and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.

5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 14.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of specific conductance analyses.*

CONDITIONS: Given references and the results of specific conductance analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal specific conductance levels found in this unit process:
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal specific conductance levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.

4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal specific conductance levels for the unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 14.6: *Plan the laboratory control procedures for monitoring specific conductance.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for specific conductance.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring specific conductance.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring specific conductance.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for specific conductance.
2. Describe sampling locations and the frequency and methods of analysis for monitoring specific conductance.
3. Discuss requirements for equipment, storage, records and reports for monitoring specific conductance.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for specific conductance.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring specific conductance.
3. Discuss requirements for equipment, storage, records and reports for monitoring specific conductance.
4. Work in small groups to plan the laboratory control procedures for monitoring specific conductance.

<<<<<<>>>>>>

OBJECTIVE 14.7: *Explain the theory behind the specific conductance analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the meaning of conductance and how it relates to the ionic strength of the water.

Explain how the ionic strength of wastewater affects treatment.

List the major ions which increase conductance.

Describe the effects of temperature on the specific conductivity of a solution and how these effects are easily minimized.

INSTRUCTOR ACTIVITY:

1. Explain the meaning of conductance and how it relates to the ionic strength of the water.
2. State the major ions which increase conductance.
3. Discuss the effects of temperature on the specific conductivity of a solution and how these effects are easily minimized.

STUDENT ACTIVITY:

1. Discuss the meaning of conductance and how it relates to the ionic strength of the water.
2. List the major ions which increase conductance.
3. State the effects of temperature on the specific conductivity of a solution and how these effects are easily minimized.

<<<<<<>>>>>>

Module 15

TURBIDITY

PURPOSE: *In this module the student will learn to determine the turbidity of a sample of wastewater by using the turbidimeter method. In this analysis colloids are measured by ascertaining how much light is scattered as it passes through the sample. The clarity of water determines its aesthetic acceptability. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

15.1 Describe the sampling procedures for the turbidity analysis.
15.2 Perform the sampling procedures for the turbidity analysis.
15.3 Describe the turbidimeter method for turbidity analysis.
15.4 Perform the turbidity analysis.
15.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of turbidity analyses.
15.6 Plan the laboratory control procedures for monitoring turbidity.
15.7 Explain the theory behind the turbidity analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
turbidity-free water or kaolin	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 100 ml	x	
bottles, 4 oz	x	
bottles for visual comparison	x	
candle turbidimeter	x	
graduated cylinders, 100 ml	x	
pipets, volumetric, 5, 10, 20 and 25 ml	x	
volumetric flasks, 50 and 100 ml	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 833 866 1033 1034 1078 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 15.1: *Describe the sampling procedures for the turbidity analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 350; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 467; Method for Chemical Analysis of Water and Wastes, p. 308;* and this plant location for grab samples:
effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers. List this information to appear on each container:
date
place
time
name of person who collected the sample

Name and describe the sampling equipment needed.

Explain conditions to avoid while sampling and transporting the sample.

Describe the best time and conditions for obtaining a representative sample.

State one method for sample preservation and give the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 15.2:

Perform the sampling procedures for the turbidity analysis.

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for grab samples.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions

3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 15.3: *Describe the turbidimeter method for turbidity analysis.*

CONDITIONS: Given a standard reference, the formula for calculating turbidity and turbidity data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for pipetting samples.

Explain how this safety precaution protects employees.

List the major steps in the analysis:
  preparation of standard suspensions
  estimation with candle turbidimeter
  estimation with bottle standards

Describe the procedures for recording data.

Calculate the turbidity.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for pipetting samples.
3. Describe the major steps in the turbidity analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating turbidity, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when pipetting samples.

3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 15.4: *Perform the turbidity analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the turbidity and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the turbidity and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 15.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of turbidity analyses.*

CONDITIONS: Given references and the results of turbidity analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal turbidity levels found in this unit process:
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal turbidity levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal turbidity levels for the unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 15.6:

Plan the laboratory control procedures for monitoring turbidity.

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for turbidity.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring turbidity.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring turbidity.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for turbidity.
2. Describe sampling locations and the frequency and methods of analysis for monitoring turbidity.
3. Discuss requirements for equipment, storage, records and reports for monitoring turbidity.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for turbidity.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring turbidity.
3. Discuss requirements for equipment, storage, records and reports for monitoring turbidity.
4. Work in small groups to plan the laboratory control procedures for monitoring turbidity.

<<<<<<>>>>>>

OBJECTIVE 15.7: *Explain the theory behind the turbidity analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Define turbidity.

Discuss the role of turbidity analysis in the purification of natural waters.

Explain how turbidity results will be affected by:
air bubbles
dirty glassware
suspensions of different types of particulate matter
vibrations disturbing the surface

INSTRUCTOR ACTIVITY:

1. State the definition of turbidity.
2. Explain the role of turbidity analysis in the purification of natural waters.
3. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

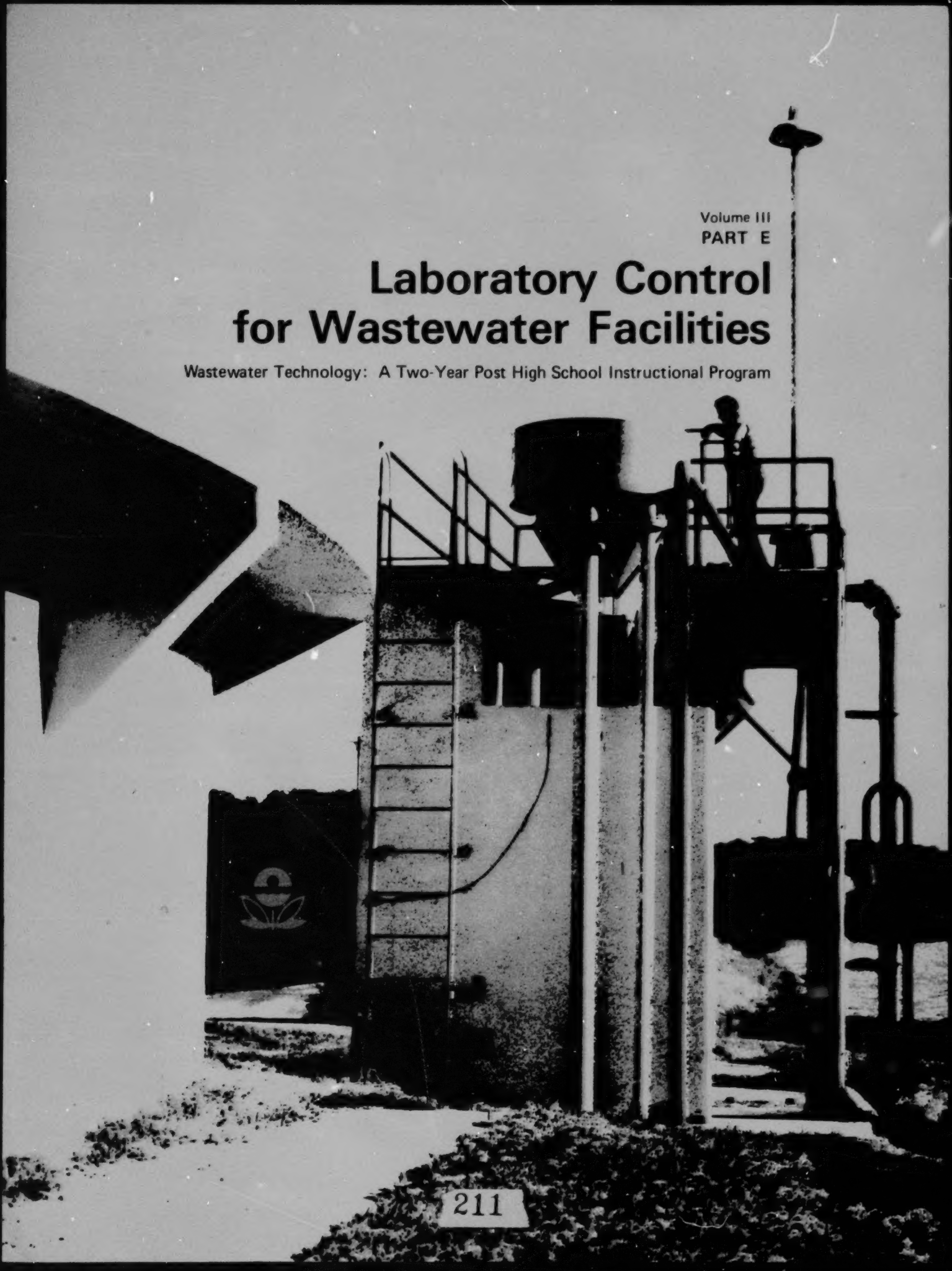
1. Define turbidity.
2. Discuss the role of turbidity analysis in the purification of natural waters.
3. Discuss the interferences.

<<<<<<>>>>>>

Volume III
PART E

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program



LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part E

Ammonia Nitrogen
Kjeldahl Nitrogen
Nitrate Nitrogen
Nitrite Nitrogen
Orthophosphate
Total Phosphorus

An Instructor's Guide for Use of Instructional Material In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page
PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. . . . . Part A
Module B National Pollutant Discharge Elimination System. . . . . . . Part A
Module C Safety . . . . Part A
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . Part B
Module 3 Chloride . . . . Part B
Module 4 pH . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. . . . . Part C
Module 7 Chemical Oxygen Demand . . . . Part C
Module 8 Chlorine Requirement . . . . Part C
Module 9 Dissolved Oxygen . . . . Part C
Module 10 Fecal Coliform . . . . Part C
Module 11 Total Residual Chlorine. . . . . Part C
Module 12 Color. . . . . Part D
Module 13 Grease . . . . Part D
Module 14 Specific Conductance . . . . Part D
Module 15 Turbidity. . . . . Part D
Module 16 Ammonia Nitrogen 11
Module 17 Kjeldahl Nitrogen. 21
Module 18 Nitrate Nitrogen 31
Module 19 Nitrite Nitrogen 41
Module 20 Orthophosphate 51
Module 21 Total Phosphorus 61
Module 22 Settleable Matter. . . . . Part F
Module 23 Total Solids . . . . Part F
Module 24 Total Dissolved Solids . . . . Part F
Module 25 Total Suspended Solids . . . . Part F
Module 26 Total Volatile Solids. . . . . Part F
Module 27 Characteristics of Activated Sludge. . . . . Part G
Module 28 Sludge Conditioning. Part G
Module 29 Sludge Digester Gas. Part G

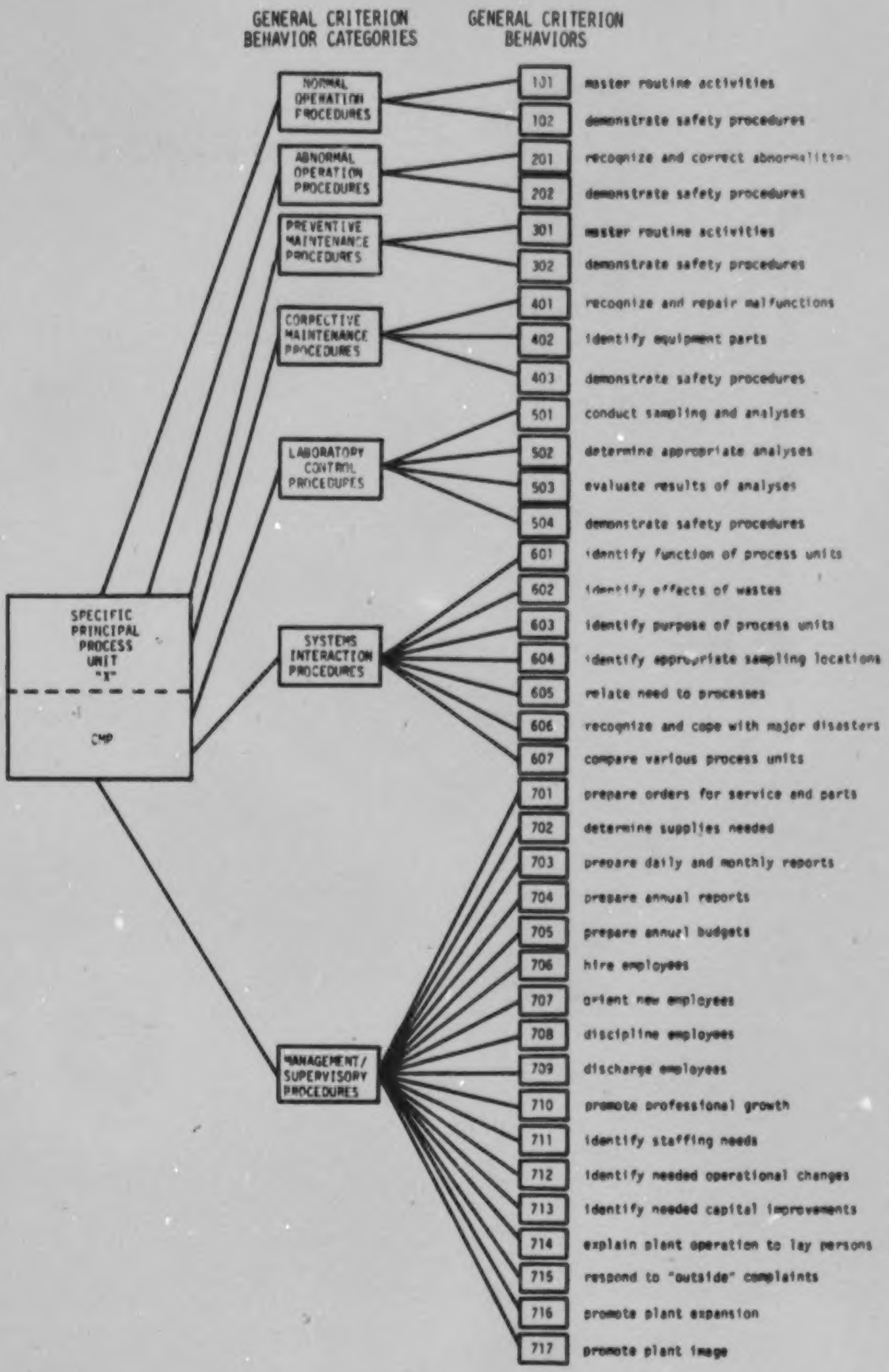

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
NORMAL OPERATION PROCEDURES
101 master routine activities
102 demonstrate safety procedures
ABNORMAL OPERATION PROCEDURES
201 recognize and correct abnormalities
202 demonstrate safety procedures
PREVENTIVE MAINTENANCE PROCEDURES
301 master routine activities
302 demonstrate safety procedures
CORRECTIVE MAINTENANCE PROCEDURES
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
LABORATORY CONTROL PROCEDURES
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
SYSTEMS INTERACTION PROCEDURES
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
MANAGEMENT/ SUPERVISORY PROCEDURES
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant*. If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program.* Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures.*)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 16

AMMONIA NITROGEN

PURPOSE: *In this module the student will learn to determine the amount of ammonia nitrogen in a sample of wastewater by using the nesslerization method. This analysis measures ammonia nitrogen by visual comparison of the sample with standards of known concentration. Ammonia in the wastestream indicates recent contamination of a water source with nitrogenous materials. Eutrophication and the nature of the chlorine residual are affected by ammonia. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

16.1 Describe the sampling procedures for the ammonia nitrogen analysis.

16.2 Perform the sampling procedures for the ammonia nitrogen analysis.

16.3 Describe the nesslerization method for ammonia nitrogen analysis.

16.4 Perform the ammonia nitrogen analysis.

16.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of ammonia nitrogen analyses.

16.6 Plan the laboratory control procedures for monitoring ammonia nitrogen.

16.7 Explain the theory behind the ammonia nitrogen analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
ammonia-free water	x	
ammonium chloride, anhydrous	x	
boric acid	x	
cobaltous chloride	x	
EDTA or Rochelle salt	x	
hydrochloric acid, concentrated	x	
mercuric iodide	x	
phenylarsine oxide	x	
potassium chloroplatinate	x	
potassium iodide	x	
sodium arsenite	x	

CHEMICALS: *continued*

	ANALYSIS	SAMPLING
sodium hydroxide solution, 1*N*, 6*N* and .3*N*	x	
sodium sulfite	x	
sodium thiosulfate	x	
sulfuric acid, 0.02*N* and 1*N*	x	
zinc sulfate	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 200 ml	x	
bottles, 32 oz	x	
burner	x	
distillation apparatus	x	
drying oven	x	
Erlenmeyer flasks, 500 ml	x	
glass beads	x	
graduated cylinders, 10 and 100 ml	x	
hot plate	x	
pH meter	x	
refrigerator		x
rubber tubing	x	
spectrophotometer, filterphotometer or Nessler tubes	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 467 488 833 866 1025 1033 1034 1079 1125
1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 16.1: *Describe the sampling procedures for the ammonia nitrogen analysis.*

CONDITIONS: Given *Method for Chemical Analysis of Water and Wastes, p. 134* and these plant locations for grab and composite samples:
- influent
- secondary sedimentation tank
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place

time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 16.2: *Perform the sampling procedures for the ammonia nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will;

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 16.3: *Describe the nesslerization method for ammonia nitrogen analysis.*

CONDITIONS: Given a standard reference, the formula for calculating ammonia nitrogen and ammonia nitrogen data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for handling phenylarsine oxide and sodium arsenite, working with acids and bases and preparing Nessler reagent.

Explain how these safety precautions protect employees.

List the major steps in the analysis;
  developing color
  comparison to color standards

Describe the procedures for recording data.

Calculate the ammonia nitrogen.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.

2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for handling phenylarsine oxide and sodium arsenite, working with acids and bases and preparing Nessler reagent.
3. Describe the major steps in the ammonia nitrogen analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating ammonia nitrogen, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when handling phenylarsine oxide and sodium arsenite, working with acids and bases and preparing Nessler reagent.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 16.4: *Perform the ammonia nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the ammonia nitrogen and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.

2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the ammonia nitrogen and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 16.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of ammonia nitrogen analyses.*

CONDITIONS: Given references and the results of ammonia nitrogen analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal ammonia nitrogen levels found in these unit processes:
  collection
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal ammonia nitrogen levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal ammonia nitrogen levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 16.6: *Plan the laboratory control procedures for monitoring ammonia nitrogen.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for ammonia nitrogen.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring ammonia nitrogen.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring ammonia nitrogen.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for ammonia nitrogen.
2. Describe sampling locations and the frequency and methods of analysis for monitoring ammonia nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring ammonia nitrogen.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for ammonia nitrogen.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring ammonia nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring ammonia nitrogen.
4. Work in small groups to plan the laboratory control procedures for monitoring ammonia nitrogen.

<<<<<<>>>>>>

OBJECTIVE 16.7: *Explain the theory behind the ammonia nitrogen analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of ammonia nitrogen analysis in the purification of natural waters.

Explain how ammonia nitrogen results will be affected by:

acetone
alcohols
aldehydes
aliphatic and aromatic amines
amines
magnesium and calcium bicarbonate
organic chloramines
pH
sulfide

Explain why the nesslerization method is most commonly used.

INSTRUCTOR ACTIVITY:

1. Explain the role of ammonia nitrogen analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Explain why the nesslerization method is most commonly used.

STUDENT ACTIVITY:

1. Discuss the role of ammonia nitrogen analysis in the purification of natural waters.
2. Discuss the interferences.
3. Explain why the nesslerization method is most commonly used.

<<<<<<>>>>>>

Module 17

KJELDAHL NITROGEN

PURPOSE: *In this module the student will learn to determine the Kjeldahl nitrogen in a sample of wastewater using the nesslerization method. This analysis measures the total organic nitrogen by visual comparison of the sample with standards of known concentration. The extent of eutrophication is, in part, determined by the Kjeldahl nitrogen. READ PAGES 1 to 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

17.1 Describe the sampling procedures for the Kjeldahl nitrogen analysis.
17.2 Perform the sampling procedures for the Kjeldahl nitrogen analysis.
17.3 Describe the nesslerization method for Kjeldahl nitrogen analysis.
17.4 Perform the Kjeldahl nitrogen analysis.
17.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of Kjeldahl nitrogen analyses.
17.6 Plan the laboratory control procedures for monitoring Kjeldahl nitrogen.
17.7 Explain the theory behind the Kjeldahl nitrogen analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
ammonia-free distilled water	x	
boric acid	x	
mercuric oxide	x	
methyl red indicator	x	
methylene blue indicator	x	
Nessler reagent	x	
phenolphthalein indicator	x	
potassium sulfate	x	
sodium hydroxide	x	
sodium thiosulfate, anhydrous	x	
sulfuric acid, concentrated, 0.02*N* and 6*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 and 1500 ml	x	
bottles, 8 and 32 oz	x	
burets, 25 ml	x	
drying oven	x	
Erlenmeyer flasks, 250 ml	x	
glass beads	x	
graduated cylinders, 100 and 1000 ml	x	
Kjeldahl connecting bulb	x	
Kjeldahl digestion and distillation apparatus	x	
Kjeldahl flasks, 800 ml	x	
mortar and pestal	x	
Nessler tubes, 100 ml or spectrophotometer	x	
Nessler tube support	x	
pipets, volumetric, 2, 5 and 50 ml	x	
refrigerator		x
rubber tubing	x	
rubber stoppers	x	
thermometer	x	
volumetric flasks, 1 liter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 833 866 1025 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 17.1: *Describe the sampling procedures for the Kjeldahl nitrogen analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 469; Method for Chemical Analysis of Water and Wastes, p. 149;* and these plant locations for grab and composite samples:

- influent
- secondary sedimentation tank
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.

List this information to appear on each container:

- date
- place

time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation and the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 17.2: *Perform the sampling procedures for the Kjeldahl nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for both grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 17.3: *Describe the nesslerization method for Kjeldahl nitrogen analysis.*

CONDITIONS: Given a standard reference, the formula for calculating Kjeldahl nitrogen and Kjeldahl nitrogen data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for preparing digestion reagent, distilling samples and preparing hydroxide-thiosulfate reagent.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  digestion of liquid samples
  distillation
  comparison to standards

Describe the end point of the titration.

Describe the procedures for recording data.

Calculate the Kjeldahl nitrogen.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for preparing digestion reagent, distilling samples and preparing hydroxide-thiosulfate reagent.
3. Describe the major steps in the Kjeldahl nitrogen analysis and describe the color change at the end point.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating Kjeldahl nitrogen, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when preparing digestion reagent, distilling samples and preparing hydroxide-thiosulfate reagent.
3. List the major steps in the analysis and describe the color change at the end point.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 17.4: *Perform the Kjeldahl nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the Kjeldahl nitrogen and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the Kjeldahl nitrogen and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 17.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of Kjeldahl nitrogen analyses.*

CONDITIONS: Given references and the results of the Kjeldahl nitrogen analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal Kjeldahl nitrogen levels found in these unit processes:
  collection
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing

sampling at different locations
reporting to supervisors

Determine which of these factors causes a departure from normal levels:
changes in the composition of the wastestream
changes in treatment
errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal Kjeldahl nitrogen levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal Kjeldahl nitrogen levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 17.6:	*Plan the laboratory control procedures for monitoring Kjeldahl nitrogen.*
CONDITIONS:	Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for Kjeldahl nitrogen.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring Kjeldahl nitrogen.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring Kjeldahl nitrogen.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for Kjeldahl nitrogen.
2. Describe sampling locations and the frequency and methods of analysis for monitoring Kjeldahl nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring Kjeldahl nitrogen.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for Kjeldahl nitrogen.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring Kjeldahl nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring Kjeldahl nitrogen.
4. Work in small groups to plan the laboratory control procedures for monitoring Kjeldahl nitrogen.

<<<<<<>>>>>>

OBJECTIVE 17.7: *Explain the theory behind the Kjeldahl nitrogen analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of Kjeldahl nitrogen analysis in the control of wastewater treatment processes.

Explain how Kjeldahl nitrogen results will be affected by:
nitrogen-free organic matter

Explain why the nesslerization method is most commonly used.

INSTRUCTOR ACTIVITY:

1. Explain the use of the Kjeldahl nitrogen analysis in the control of wastewater treatment processes.
2. Explain the causes and effects of interferences.
3. Explain why the nesslerization method is most commonly used.

STUDENT ACTIVITY:

1. Discuss the use of the Kjeldahl nitrogen analysis in the control of wastewater treatment processes.
2. Discuss the interferences.
3. Explain why the nesslerization method is most commonly used.

<<<<<<>>>>>>

Module 18

NITRATE NITROGEN

PURPOSE: *In this module the student will learn to determine the nitrate nitrogen in a sample of wastewater by using the cadmium reduction method. In this analysis nitrate is reduced to an equivalent amount of nitrite which is measured colorimetrically. Nitrate nitrogen is a source of oxygen, as well as a major source of nutrients. Because nitrates can cause methemoglobinemia in infants, the nitrate content of water and wastewater treatment plant effluents is controlled. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

18.1 Describe the sampling procedures for the nitrate nitrogen analysis.
18.2 Perform the sampling procedures for the nitrate nitrogen analysis.
18.3 Describe the cadmium reduction method for nitrate nitrogen analysis.
18.4 Perform the nitrate nitrogen analysis.
18.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of nitrate nitrogen analyses.
18.6 Plan the laboratory control procedures for monitoring nitrate nitrogen.
18.7 Explain the theory behind the nitrate nitrogen analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
ammonium chloride	x	
cadmium filings	x	
distilled water	x	
hydrochloric acid	x	
mercuric chloride	x	
n-(1-naphthyl)-ethylenediamine dihydrochloride	x	
nitric acid	x	
potassium nitrate	x	
sulfanilamide	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
bottles, dark, 250 ml	x	
Erlenmeyer flasks, 250 ml	x	
glass tubing	x	
glass wool	x	
graduated cylinders, 100 ml	x	
pH meter	x	
reduction columns	x	
refrigerator		x
sieve, 0.5 mm openings	x	
spectrophotometer or filter photometer	x	
volumetric flasks, 1 liter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 48 225 387 465 833 866 1025 1033 1034 1079 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 18.1: *Describe the sampling procedures for the nitrate nitrogen analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 458; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 124; Method for Chemical Analysis of Water and Wastes, p. 170;* and these plant locations for grab samples:

- secondary sedimentation tank
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 18.2: *Perform the sampling procedures for the nitrate nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.

3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 18.3: *Describe the cadmium reduction method for nitrate nitrogen analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating nitrate nitrogen and nitrate nitrogen data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for handling acids and bases and preparing sulfanilamide reagent.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  reduction of nitrate
  color measurements

Describe the procedures for recording data.

Calculate the nitrate nitrogen.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for handling acids and bases and preparing sulfanilamide reagent.
3. Describe the major steps in the nitrate nitrogen analysis.
4. Explain the procedures for recording data.

5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating nitrate nitrogen, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when handling acids and bases and preparing sulfanilamide reagent.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 18.4: *Perform the nitrate nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the nitrate nitrogen and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the nitrate nitrogen and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.

4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 18.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of nitrate nitrogen analyses.*

CONDITIONS: Given references and the results of nitrate nitrogen analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal nitrate nitrogen levels found in these unit processes:
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal nitrate nitrogen levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.

4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal nitrate nitrogen levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 18.6: *Plan the laboratory control procedures for monitoring nitrate nitrogen.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for nitrate nitrogen.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring nitrate nitrogen.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring nitrate nitrogen.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for nitrate nitrogen.
2. Describe sampling locations and the frequency and methods of analysis for monitoring nitrate nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring nitrate nitrogen.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for nitrate nitrogen.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring nitrate nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring nitrate nitrogen.
4. Work in small groups to plan the laboratory control procedures for monitoring nitrate nitrogen.

<<<<<<>>>>>>

OBJECTIVE 18.7: *Explain the theory behind the nitrate nitrogen analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will;

Discuss the role of nitrate nitrogen analysis in the purification of natural waters.

Explain how nitrate nitrogen results will be affected by:
pH
turbidity

Explain why the cadmium reduction method is commonly used.

State the chemical equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain the role of nitrate nitrogen analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Present the equation, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Discuss the role of nitrate nitrogen analysis in the purification of natural waters.
2. Discuss the interferences.
3. State the equations, explaining the reactions taking place during the analysis.

<<<<<<>>>>>>

Module 19

NITRITE NITROGEN

PURPOSE: In this module the student will learn to determine the nitrite nitrogen in a sample of wastewater by using the colorimetric method. This analysis produces a highly colored azo dye which, when compared visually with standards of known concentration, indicates how much nitrite is in the wastestream. The results of this test are used to determine the extent of nitrogen degradation, because nitrite is an intermediate product in the degradation of organic nitrogen. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.

PREREQUISITES: Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.

OBJECTIVES:

19.1 Describe the sampling procedures for the nitrite nitrogen analysis.
19.2 Perform the sampling procedures for the nitrite nitrogen analysis.
19.3 Describe the colorimetric method for nitrite nitrogen analysis.
19.4 Perform the nitrite nitrogen analysis.
19.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of nitrite nitrogen analyses.
19.6 Plan the laboratory control procedures for monitoring nitrite nitrogen.
19.7 Explain the theory behind the nitrite nitrogen analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
aluminum hydroxide	x	
aluminum potassium sulfate or aluminum ammonium sulfate	x	
barium hydroxide	x	
chloroform	x	
EDTA	x	
hydrochloric acid	x	
manganese sulfate	x	
mercuric chloride		x

CHEMICALS:
continued

	ANALYSIS	SAMPLING
1-naphthylamine hydrochloride	x	
nitrite-free water	x	
potassium permanganate, 0.05*N*	x	
sodium acetate	x	
sodium nitrite	x	
sodium oxalate	x	
sulfanilic acid	x	
sulfuric acid	x	
zinc sulfate	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
aspirator	x	
balance	x	
beakers, 250 ml	x	
desiccator	x	
Erlenmeyer flasks, 250 ml	x	
filter	x	
hot plate	x	
pH meter	x	
pipets, measuring, 50 ml	x	
refrigerator	x	x
spectrophotometer, filter photometer or Nessler tubes	x	
stirring rods	x	
thermometer	x	x
volumetric flasks, 1 liter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 833 866 1025 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 19.1: *Describe the sampling procedures for the nitrite nitrogen analysis.*

CONDITIONS: Given *Method for Chemical Analysis of Water and Wastes, p. 185, p. 195* and these plant locations for grab samples:
secondary sedimentation tank
effluent

ACCEPTABLE PERFORMANCE:

The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
  date
  place
  time
  name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

Name one method of sample preservation and the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation and state the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample and give the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 19.2:

Perform the sampling procedures for the nitrite nitrogen analysis.

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Add the chemicals for preserving the sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Add chemicals to preserve the sample and transport it to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 19.3: *Describe the colorimetric method for nitrite nitrogen analysis.*

CONDITIONS: Given a standard reference, the formula for calculating nitrite nitrogen and nitrite nitrogen data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for handling acids and bases, preparing naphthylamine hydrochloride reagent and pipetting solutions.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  color development
  comparison with calibration curves

Describe the procedures for recording data.

Calculate the nitrite nitrogen.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for handling acids and bases, preparing naphthylamine hydrochloride reagent and pipetting solutions.
3. Describe the major steps in the nitrite nitrogen analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating nitrite nitrogen, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when handling acids and bases, preparing naphthylamine hydrochloride reagent and pipetting solutions.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 19.4: *Perform the nitrite nitrogen analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the nitrite nitrogen and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the nitrite nitrogen and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 19.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of nitrite nitrogen analyses.*

CONDITIONS: Given references and the results of nitrite nitrogen analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal nitrite nitrogen levels found in these unit processes:
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing

sampling at different locations
reporting to supervisors

Determine which of these factors causes a departure from normal levels:
changes in the composition of the wastestream
changes in treatment
errors in sampling
errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal nitrite nitrogen levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal nitrite nitrogen levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 19.6: *Plan the laboratory control procedures for monitoring nitrite nitrogen.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for nitrite nitrogen.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring nitrite nitrogen.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring nitrite nitrogen.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for nitrite nitrogen.
2. Describe sampling locations and the frequency and methods of analysis for monitoring nitrite nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring nitrite nitrogen.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for nitrite nitrogen.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring nitrite nitrogen.
3. Discuss requirements for equipment, storage, records and reports for monitoring nitrite nitrogen.
4. Work in small groups to plan the laboratory control procedures for monitoring nitrite nitrogen.

<<<<<<>>>>>>

OBJECTIVE 19.7: *Explain the theory behind the nitrite nitrogen analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of nitrite nitrogen analysis in the purification of natural waters.

Explain how nitrite nitrogen results will be affected by:

- antimonous ions
- auric ions
- bismuth ions
- chloroplatinate ions
- cupric ions
- ferric ions
- free available chlorine
- lead ions
- mercurous ions
- metavanadate ions
- nitrogen trichloride
- silver ions
- suspended solids

State the chemical equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain the role of nitrite nitrogen analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Present the equations, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Explain the role of nitrite nitrogen analysis in the purification of natural waters.
2. Discuss the interferences.
3. State the equations, explaining the reactions taking place during the analysis.

<<<<<<>>>>>>

Module 20

ORTHOPHOSPHATE

PURPOSE: *In this module the student will learn to determine the amount of orthophosphate in a sample of wastewater by using the ascorbic acid method. This analysis produces an intensely colored molybdenum blue complex which, when compared with standards of known concentration, indicates how much readily available orthophosphate is in the wastestream. Orthophosphate stimulates the growth of organisms and contributes to eutrophication. Phosphorus limits are often placed on effluents. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

20.1 Describe the sampling procedures for the orthophosphate analysis.
20.2 Perform the sampling procedures for the orthophosphate analysis.
20.3 Describe the ascorbic acid method for orthophosphate analysis.
20.4 Perform the orthophosphate analysis.
20.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of orthophosphate analyses.
20.6 Plan the laboratory control procedures for monitoring orthophosphate.
20.7 Explain the theory behind the orthophosphate analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
ammonium molybdate	x	
antimony potassium tartrate	x	
ascorbic acid, 0.1*M*	x	
distilled water	x	
ethyl alcohol or isopropyl alcohol	x	
hydrochloric acid	x	
potassium dihydrogen phosphate	x	
sulfuric acid	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
bottles, dark, 250 ml	x	
Erlenmeyer flasks, 250 ml	x	
hot plate	x	
pipets, measuring, 25 ml	x	
refrigerator		x
spectrophotometer or filter photometer	x	
thermometer	x	
volumetric flasks, 1 liter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottles	x	

RESOURCES: 225 387 465 488 542 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 20.1: *Describe the sampling procedures for the orthophosphate analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 532; Annual Book of Standards Part 23, Water, Atmospheric Analysis, p. 42; Method for Chemical Analysis of Water and Wastes, p. 235;* and these plant locations for grab samples:

- secondary sedimentation tank
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.

List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 20.2: *Perform the sampling procedures for the orthophosphate analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 20.3: *Describe the ascorbic acid method for orthophosphate analysis.*

CONDITIONS: Given a standard reference, the formula for calculating orthophosphate and orthophosphate data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for working with hydrochloric and sulfuric acid and pipetting samples.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
color development
comparison with calibration curves

Describe the procedures for recording data.

Calculate the orthophosphate.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for working with hydrochloric and sulfuric acid and pipetting samples.
3. Describe the major steps in the orthophosphate analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.

6. Present the formula for calculating orthophosphate, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when working with hydrochloric and sulfuric acid and pipetting samples.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 20.4: *Perform the orthophosphate analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the orthophosphate and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the orthophosphate and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.

3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 20.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of orthophosphate analyses.*

CONDITIONS: Given references and the results of orthophosphate analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal orthophosphate levels found in these unit processes:
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal orthophosphate levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.

3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal orthophosphate levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 20.6: *Plan the laboratory control procedures for monitoring orthophosphate.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for orthophosphate.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring orthophosphate.

Determine requirements for:
- library
- records and reports
- storage for equipment and supplies
- support equipment
- test equipment

Prepare laboratory control reports and procedures for monitoring orthophosphate.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for orthophosphate.
2. Describe sampling locations and the frequency and methods of analysis for monitoring orthophosphate.
3. Discuss requirements for equipment, storage, records and reports for monitoring orthophosphate.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for orthophosphate.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring orthophosphate.
3. Discuss requirements for equipment, storage, records and reports for monitoring orthophosphate.
4. Work in small groups to plan the laboratory control procedures for monitoring orthophosphate.

<<<<<<>>>>>>

OBJECTIVE 20.7: *Explain the theory behind the orthophosphate analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of orthophosphate analysis in the purification of natural waters.

Explain how orthophosphate results will be affected by:
arsenates
hexavalent chromium and nitrite
silicate
sulfide
turbidity

State the chemical equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain the role of orthophosphate analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.

3. Present the equations, explaining the reactions taking place during the analysis.

STUDENT ACTIVITY:

1. Discuss the role of orthophosphate analysis in the purification of natural waters.
2. Discuss the interferences.
3. State the equations, explaining the reactions taking place during the analysis.

<<<<<<>>>>>>

Module 21

TOTAL PHOSPHORUS

PURPOSE: *In this module the student will learn to determine the total phosphorus in a sample of wastewater by using the ascorbic acid method. This analysis produces an intensely colored molybdenum blue complex which, when compared with standards of known concentration, indicates the total phosphorus in the wastestream. Because it is a nutrient, phosphorus limits are often placed on effluents. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

21.1 Describe the sampling procedures for the total phosphorus analysis.
21.2 Perform the sampling procedures for the total phosphorus analysis.
21.3 Describe the ascorbic acid method for total phosphorus analysis.
21.4 Perform the total phosphorus analysis.
21.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total phosphorus analyses.
21.6 Plan the laboratory control procedures for monitoring total phosphorus.
21.7 Explain the theory behind the total phosphorus analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
ammonium molybdate	x	
antimony potassium tartrate	x	
ascorbic acid, 0.1M	x	
distilled water	x	
ethyl alcohol or isopropyl alcohol	x	
hydrochloric acid	x	
potassium dihydrogen phosphate	x	
sulfuric acid	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
bottles, dark, 250 ml	x	
Erlenmeyer flasks, 250 ml	x	
graduated cylinders, 50 ml	x	
hot plate	x	
pipets, volumetric, 10 ml	x	
refrigerator		x
spectrophotometer or filter photometer	x	
thermometer	x	
volumetric flasks, 1 liter	x	
water sample bottles with stoppers, 125 ml		x
weighing bottle	x	

RESOURCES: 225 387 465 488 542 833 850 866 1025 1033 1034 1079 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 21.1: *Describe the sampling procedures for the total phosphorus analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater*, p. 532; *Method for Chemical Analysis of Water and Wastes*, p. 259; and these plant locations for grab samples:

- influent
- secondary sedimentation tank
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State one method of sample preservation.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Describe sample preservation.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State one method for preserving a sample.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 21.2:

Perform the sampling procedures for the total phosphorus analysis.

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.

3. Demonstrate a method for preserving and transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 21.3: *Describe the ascorbic acid method for total phosphorus analysis.*

CONDITIONS: Given a standard reference, the formula for calculating total phosphorus and total phosphorus data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for working with hydrochloric and sulfuric acid and pipetting samples.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  color development
  comparison with calibration curves

Describe the procedures for recording data.

Calculate the total phosphorus.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for working with hydrochloric and sulfuric acid and pipetting samples.

3. Describe the major steps in the total phosphorus analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total phosphorus, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when working with hydrochloric and sulfuric acid and pipetting samples.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 21.4: *Perform the total phosphorus analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total phosphorus and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.

7. Explain how to record data, calculate the total phosphorus and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 21.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total phosphorus analyses.*

CONDITIONS: Given references and the results of total phosphorus analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal total phosphorus levels found in these unit processes:
  collection
  secondary sedimentation
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal total phosphorus levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal total phosphorus levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 21.6:

Plan the laboratory control procedures for monitoring total phosphorus.

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for total phosphorus.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total phosphorus.

Determine requirements for:
library

records and reports
storage for equipment and supplies
support equipment
test equipment

Prepare laboratory control reports and procedures for monitoring total phosphorus.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total phosphorus.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total phosphorus.
3. Discuss requirements for equipment, storage, records and reports for monitoring total phosphorus.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total phosphorus.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total phosphorus.
3. Discuss requirements for equipment, storage, records and reports for monitoring total phosphorus.
4. Work in small groups to plan the laboratory control procedures for monitoring total phosphorus.

<<<<<<>>>>>>

OBJECTIVE 21.7: *Explain the theory behind the total phosphorus analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of total phosphorus analysis in the purification of natural waters.

Explain how total phosphorus results will be affected by:

arsenates
hexavalent chromium and nitrite
silicate
sulfide
turbidity

State the chemical equations, explaining the reactions taking place during the analysis.

INSTRUCTOR ACTIVITY:

1. Explain the role of total phosphorus analysis in the purification of natural waters.
2. Explain the causes and effects of interferences.
3. Present the equations, explaining the reactions taking place during the total phosphorus analysis.

STUDENT ACTIVITY:

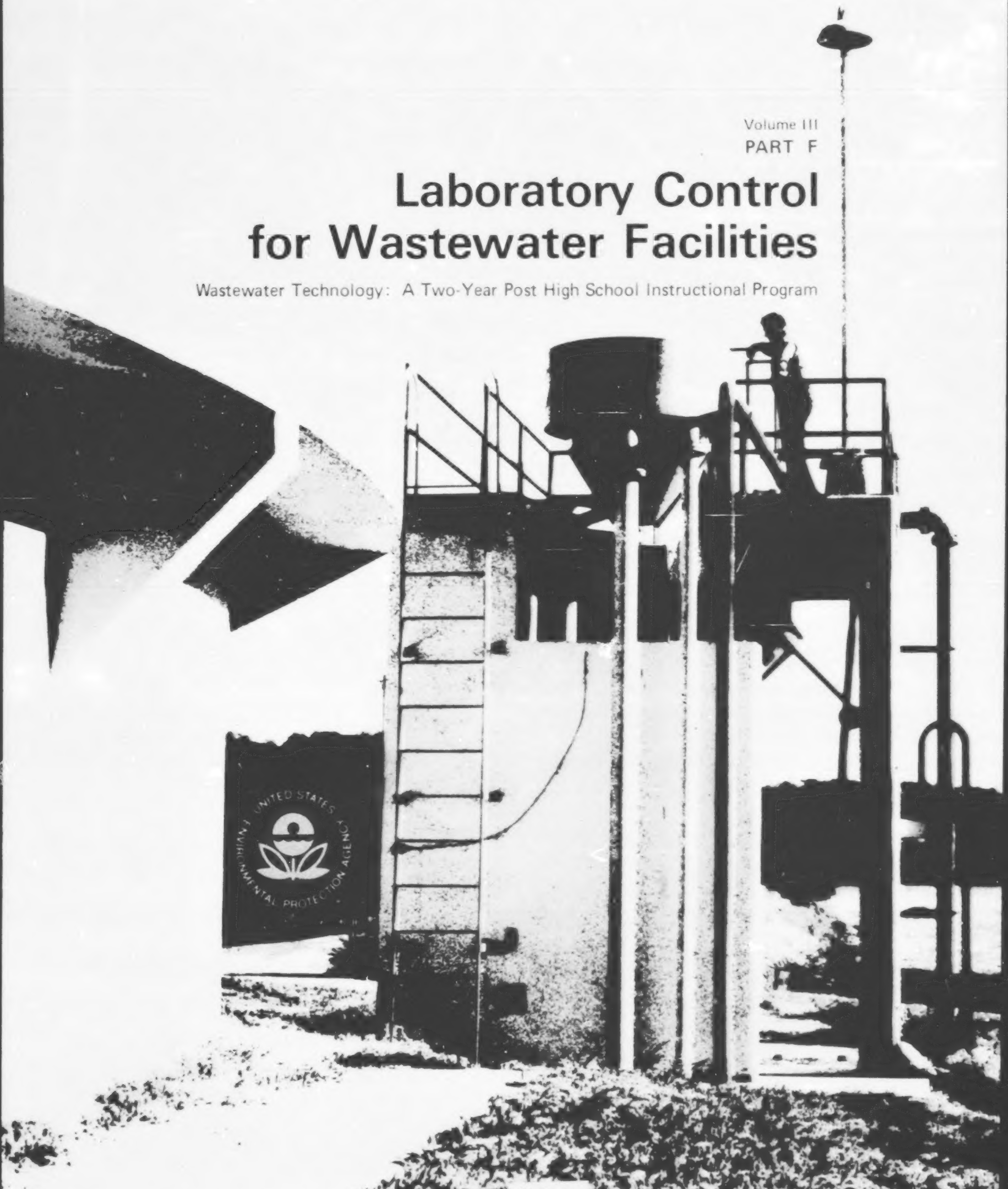
1. Discuss the role of total phosphorus analysis in the purification of natural waters.
2. Discuss the interferences.
3. State the equations, explaining the reactions taking place during the total phosphorus analysis.

<<<<<<>>>>>>

Volume III
PART F

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part F

Settleable Matter
Total Solids
Total Dissolved Solids
Total Suspended Solids
Total Volatile Solids

An Instructor's Guide for Use of Instructional Material In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page

PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. . . . . Part A
Module B National Pollutant Discharge Elimination System. . . . . Part A
Module C Safety . . . . . Part A
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . . Part B
Module 3 Chloride . . . . . Part B
Module 4 pH . . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. . . . . Part C
Module 7 Chemical Oxygen Demand . . . . . Part C
Module 8 Chlorine Requirement . . . . . Part C
Module 9 Dissolved Oxygen . . . . . Part C
Module 10 Fecal Coliform . . . . . Part C
Module 11 Total Residual Chlorine. . . . . Part C
Module 12 Color. . . . . Part D
Module 13 Grease . . . . . Part D
Module 14 Specific Conductance . . . . . Part D
Module 15 Turbidity. . . . . Part D
Module 16 Ammonia Nitrogen . . . . . Part E
Module 17 Kjeldahl Nitrogen. . . . . Part E
Module 18 Nitrate Nitrogen . . . . . Part E
Module 19 Nitrite Nitrogen . . . . . Part E
Module 20 Orthophosphate . . . . . Part E
Module 21 Total Phosphorus . . . . . Part E
Module 22 Settleable Matter. 11
Module 23 Total Solids 19
Module 24 Total Dissolved Solids 27
Module 25 Total Suspended Solids 37
Module 26 Total Volatile Solids. 47
Module 27 Characteristics of Activated Sludge. . . . . Part G
Module 28 Sludge Conditioning. . . . . Part G
Module 29 Sludge Digester Gas. . . . . Part G

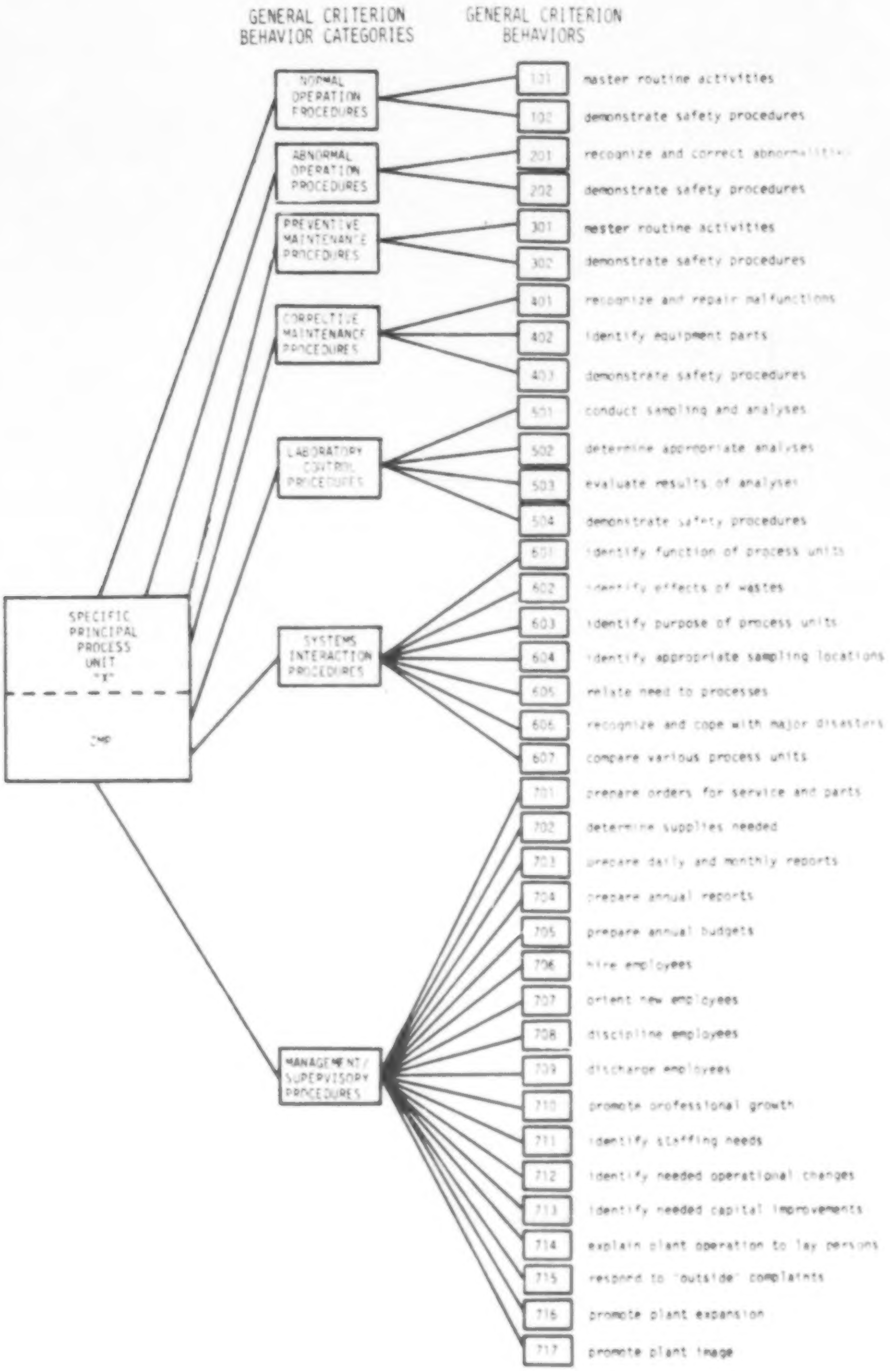

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
NORMAL OPERATION PROCEDURES
ABNORMAL OPERATION PROCEDURES
PREVENTIVE MAINTENANCE PROCEDURES
CORRECTIVE MAINTENANCE PROCEDURES
LABORATORY CONTROL PROCEDURES
SYSTEMS INTERACTION PROCEDURES
MANAGEMENT/ SUPERVISORY PROCEDURES
101 master routine activities
102 demonstrate safety procedures
201 recognize and correct abnormalities
202 demonstrate safety procedures
301 master routine activities
302 demonstrate safety procedures
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant*. If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 22

SETTLEABLE MATTER

PURPOSE: *In this module the student will learn to determine the settleable matter in a sample of wastewater by using the Imhoff cone method. This analysis measures the volume of settleable matter after the sample stands undisturbed for a set length of time. Results of the test enable the operator to anticipate storage problems with solids in sedimentation units and digesters and problems with other treatment units. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

22.1 Describe the sampling procedures for the settleable matter analysis.
22.2 Perform the sampling procedures for the settleable matter analysis.
22.3 Describe the Imhoff cone method for settleable matter analysis.
22.4 Perform the settleable matter analysis.
22.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of settleable matter analyses.
22.6 Plan the laboratory control procedures for monitoring settleable matter.
22.7 Explain the theory behind the settleable matter analysis.

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
Imhoff cones	x	
siphon set up	x	
stirring rod	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 579 833 866 1033 1034 1125 1326 1336 1346 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 22.1: *Describe the sampling procedures for the settleable matter analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 539* and these plant locations for grab samples:

- influent
- screen and grinder effluent
- grit chamber
- primary sedimentation tank

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 22.2: *Perform the sampling procedures for the settleable matter analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample for settleable matter analysis from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 22.3: *Describe the Imhoff cone method for settleable matter analysis.*

CONDITIONS: Given a standard reference, the formula for calculating settleable matter and settleable matter data.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare or obtain a list of equipment needed to perform the analysis.

List the major steps in the analysis:
settling
stirring sides of cone
final settling

Describe the procedures for recording data.

Calculate the settleable matter.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Describe the major steps in the settleable matter analysis.
3. Explain the procedures for recording data.
4. Check the flow chart for the analysis which the student has prepared.
5. Present the formula for calculating settleable matter, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. List the major steps in the analysis.
3. List the procedures for recording data.
4. Develop a flow chart for the analysis.
5. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 22.4: *Perform the settleable matter analysis.*

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE:

The student will:

Set up the equipment.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the settleable matter and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the sample for the analysis.
3. Perform the analysis on a sample.
4. Observe the student demonstrating the analysis in a dry run in the laboratory.
5. Observe the student performing the analysis in the laboratory.
6. Explain how to record data, calculate the settleable matter and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the sample for the analysis.
3. Observe the instructor demonstrating the analysis.
4. Demonstrate the analysis in a dry run in the laboratory.
5. Perform the analysis.
6. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 22.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of settleable matter analyses.

CONDITIONS:

Given references and the results of settleable matter analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal settleable matter levels found in these unit processes:
  collection
  screening and grinding
  grit removal
  primary sedimentation

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling

errors in laboratory technique
errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal settleable matter levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal settleable matter levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 22.6: *Plan the laboratory control procedures for monitoring settleable matter.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for settleable matter.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring settleable matter.

Determine requirements for:
library
records and reports
storage for equipment and supplies
support equipment
test equipment

Prepare laboratory control reports and procedures for monitoring settleable matter.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for settleable matter.
2. Describe sampling locations and the frequency and methods of analysis for monitoring settleable matter.
3. Discuss requirements for equipment, storage, records and reports for monitoring settleable matter.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for settleable matter.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring settleable matter.
3. Discuss requirements for equipment, storage, records and reports for monitoring settleable matter.
4. Work in small groups to plan the laboratory control procedures for monitoring settleable matter.

<<<<<<>>>>>>

OBJECTIVE 22.7: *Explain the theory behind the settleable matter analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of settleable matter analysis in wastewater treatment plant operation.

Explain how settleable matter results will be affected by:
grease

solid material
temperature changes

INSTRUCTOR ACTIVITY:

1. Explain the role of settleable matter analysis in wastewater treatment plant operation.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of settleable matter analysis in wastewater treatment plant operation.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 23

TOTAL SOLIDS

PURPOSE: *In this module the student will learn to determine the total solids in a sample of wastewater by using the gravimetric method. This analysis measures the total organic and inorganic solids in the sample by evaporation. The results of the test determine whether water is suitable for domestic and industrial uses. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

23.1 Describe the sampling procedures for the total solids analysis.
23.2 Perform the sampling procedures for the total solids analysis.
23.3 Describe the gravimetric method for total solids analysis.
23.4 Perform the total solids analysis.
23.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total solids analyses.
23.6 Plan the laboratory control procedures for monitoring total solids.
23.7 Explain the theory behind the total solids analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
sodium hydroxide, 1*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
burner	x	
desiccator, 250 ml	x	
drying oven	x	
evaporating dish	x	
forceps	x	
graduated cylinders, 100 ml	x	

EQUIPMENT:
continued

	ANALYSIS	SAMPLING
pH meter	x	
steam bath	x	
support frame for bath	x	
thermometer	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 580 581 833 866 1033 1034 1125 1326 1336 1370 1461 1473 1623

<<<<<<>>>>>>

OBJECTIVE 23.1: *Describe the sampling procedures for the total solids analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 535; Method for Chemical Analysis of Water and Wastes, p. 280;* and these plant locations for grab samples:

influent
effluent

and this plant location for composite samples:

effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

date
place
time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.

3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 23.2:

Perform the sampling procedures for the total solids analysis.

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 23.3: *Describe the gravimetric method for total solids analysis.*

CONDITIONS: Given a standard reference, the formula for calculating total solids and total solids data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for using drying ovens, using desiccators and handling hot evaporation dishes.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  evaporation
  drying to constant weight

Describe the procedures for recording data.

Calculate the total solids.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for using drying ovens, using desiccators and handling hot evaporation dishes.
3. Describe the major steps in the total solids analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total solids, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.

2. State the safety precautions followed when using drying ovens, using desiccators and handling hot evaporation dishes.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 23.4: *Perform the total solids analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total solids and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the total solids and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 23.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total solids analyses.*

CONDITIONS: Given references and the results of total solids analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal total solids levels found in these unit processes:
  collection
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal total solids levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal total solids levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 23.6: *Plan the laboratory control procedures for monitoring total solids.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for total solids.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total solids.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring total solids.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total solids.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total solids.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total solids.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total solids.
4. Work in small groups to plan the laboratory control procedures for monitoring total solids.

<<<<<<>>>>>>

OBJECTIVE 23.7: *Explain the theory behind the total solids analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of total solids analysis in the determination of water quality.

Explain how total solids results will be affected by:
carbon dioxide
drying time
filter characteristics
grease content
ignition time
pH
solids crystallizing as hydrates
temperatures
volatile minerals

INSTRUCTOR ACTIVITY:

1. Explain the role of total solids analysis in the determination of water quality.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of total solids analysis in the determination of water quality.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 24

TOTAL DISSOLVED SOLIDS

PURPOSE: *In this module the student will learn to determine the total dissolved solids in a sample of wastewater by using the gravimetric method. This analysis measures the soluble solids by determining the difference between the residue on evaporation and the total suspended matter. Results of this test are used in investigations of the efficiency of advanced treatment units. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

24.1 Describe the sampling procedures for the total dissolved solids analysis.
24.2 Perform the sampling procedures for the total dissolved solids analysis.
24.3 Describe the gravimetric method for total dissolved solids analysis.
24.4 Perform the total dissolved solids analysis.
24.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total dissolved solids analyses.
24.6 Plan the laboratory control procedures for monitoring total dissolved solids.
24.7 Explain the theory behind the total dissolved solids analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
distilled water	x	
sodium hydroxide, 1*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
aspirator	x	
balance	x	
burner	x	

EQUIPMENT: *continued*

	ANALYSIS	SAMPLING
desiccator	x	
drying oven	x	
evaporating dish	x	
filter flasks, 1000 ml	x	
filter holders	x	
forceps	x	
glass fiber filter discs, 5.5 cm	x	
graduated cylinders, 100 ml	x	
pH meter	x	
steam bath	x	
stirring rods	x	
support frame for bath	x	
thermometer	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 833 866 1033 1034 1079 1125 1326 1336 1370 1461 1473 1623

<<<<<<>>>>>>

OBJECTIVE 24.1: *Describe the sampling procedures for the total dissolved solids analysis.*

CONDITIONS: Given *Method for Chemical Analysis of Water and Wastes, p. 275* and this plant location for grab and composite samples:
  effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment.

Explain conditions to avoid while sampling and transporting the sample.

Describe the best time and conditions for obtaining a representative sample.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 24.2: *Perform the sampling procedures for the total dissolved solids analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain samples.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

5. Observe the student performing the sampling procedures in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 24.3:

Describe the gravimetric method for total dissolved solids analysis.

CONDITIONS:

Given a standard reference, the formula for calculating total dissolved solids and total dissolved solids data.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for filtering samples, using drying ovens and handling desiccators.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
filtration
evaporation
drying to constant weight

Describe the procedures for recording data.

Calculate the total dissolved solids.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for filtering samples, using drying ovens and handling desiccators.
3. Describe the major steps in the total dissolved solids analysis.
4. Explain the procedures for recording data.

5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total dissolved solids, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when filtering samples, using drying ovens and handling desiccators.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 24.4: *Perform the total dissolved solids analysis.*

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant location for samples.

ACCEPTABLE PERFORMANCE:

The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total dissolved solids and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the total dissolved solids and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 24.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total dissolved solids analyses.

CONDITIONS:

Given references and the results of total dissolved solids analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal total dissolved solids levels found in this unit process:
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations.

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit process is operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal total dissolved solids levels.
2. Discuss additional laboratory tests and different

sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit process is operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal total dissolved solids levels for this unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit process is operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 24.6:

Plan the laboratory control procedures for monitoring total dissolved solids.

CONDITIONS:

Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE:

The student will:

List the tests and measurements for total dissolved solids.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total dissolved solids.

Determine requirements for:
library
records and reports
storage for equipment and supplies

support equipment
test equipment

Prepare laboratory control reports and procedures for monitoring total dissolved solids.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total dissolved solids.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total dissolved solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total dissolved solids.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total dissolved solids.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total dissolved solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total dissolved solids.
4. Work in small groups to plan the laboratory control procedures for monitoring total dissolved solids.

<<<<<<>>>>>>

OBJECTIVE 24.7: *Explain the theory behind the total dissolved solids analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of total dissolved solids analysis in the determination of water quality.

Explain how total dissolved solids analysis results will be affected by:
carbon dioxide
drying time
filter characteristics
high grease content
ignition time
pH

solids crystallizing as hydrates
temperature
volatile minerals

INSTRUCTOR ACTIVITY:

1. Explain the role of the total dissolved solids analysis in the determination of water quality.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of total dissolved solids analysis in the determination of water quality.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 25

TOTAL SUSPENDED SOLIDS

PURPOSE: *In this module the student will learn to determine the total suspended solids in a sample of wastewater by using the gravimetric method. This analysis measures the total suspended solids after drying the filtered residue of the sample. Results of the test are used to evaluate the strength of domestic wastewaters and to determine the efficiency of treatment units. A principal function of wastewater treatment is the removal of suspended solids or their conversion to well-digested and stabilized materials which will appear as dissolved solids in the effluent. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

25.1 Describe the sampling procedures for the total suspended solids analysis.
25.2 Perform the sampling procedures for the total suspended solids analysis.
25.3 Describe the gravimetric method for total suspended solids analysis.
25.4 Perform the total suspended solids analysis.
25.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total suspended solids analyses.
25.6 Plan the laboratory control procedures for monitoring total suspended solids.
25.7 Explain the theory behind the total suspended solids analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
distilled water	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
aspirator	x	
balance	x	
desiccator	x	
drying oven	x	
filter flasks, 1000 ml	x	
filter holders	x	
glass fiber filter discs, 5.5 cm	x	
graduated cylinders, 100 ml	x	
stirring rods	x	

RESOURCES: 142 225 387 465 582 583 833 866 902 1033 1034 1125
1326 1336 1345 1370 1461 1473 1623 1627

<<<<<<>>>>>>

OBJECTIVE 25.1: *Describe the sampling procedures for the total suspended solids analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 537; Method for Chemical Analysis of Water and Wastes, p. 278;* and these plant locations for grab and composite samples:

- screen and grinder effluent
- grit chamber
- primary sedimentation tank
- secondary sedimentation tank
- pond
- sludge dewaterer
- solids disposal sight
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 25.2: *Perform the sampling procedures for the total suspended solids analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.

3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 25.3: *Describe the gravimetric method for total suspended solids analysis.*

CONDITIONS: Given a standard reference, the formula for calculating total suspended solids and total suspended solids data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for drying in muffle furnaces and ovens, pipetting samples and handling hot crucibles.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  filtration of sample
  drying of sample

Describe the procedures for recording data.

Calculate the total suspended solids.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for drying in muffle furnaces and ovens, pipetting samples and handling hot crucibles.

3. Describe the major steps in the total suspended solids analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total suspended solids, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when drying in muffle furnaces and ovens, pipetting samples and handling hot crucibles.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 25.4: *Perform the total suspended solids analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total suspended solids and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the sample for the analysis.
3. Perform the analysis on a sample.
4. Observe the student demonstrating the analysis in a dry run in the laboratory.
5. Observe the student performing the analysis in the laboratory.
6. Explain how to record data, calculate the total suspended solids and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the sample for the analysis.
3. Observe the instructor demonstrating the analysis.
4. Demonstrate the analysis in a dry run in the laboratory.
5. Perform the analysis.
6. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 25.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total suspended solids analyses.*

CONDITIONS: Given references and the results of total suspended solids analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal total suspended solids levels found in these unit processes:
  screening and grinding
  grit removal
  primary sedimentation
  secondary sedimentation
  pond stabilization
  sludge dewatering
  solids disposal
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal total suspended solids levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal total suspended solids levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 25.6: *Plan the laboratory control procedures for monitoring total suspended solids.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for total suspended solids.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total suspended solids.

Determine requirements for:
library
records and reports
storage for equipment and supplies
support equipment
test equipment

Prepare laboratory control reports and procedures for monitoring total suspended solids.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total suspended solids.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total suspended solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total suspended solids.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total suspended solids.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total suspended solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total suspended solids.
4. Work in small groups to plan the laboratory control procedures for monitoring total suspended solids.

<<<<<<>>>>>>

OBJECTIVE 25.7: *Explain the theory behind the total suspended solids analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of total suspended solids analysis in the determination of water quality.

Explain how total suspended solids results will be affected by:
drying time
filter characteristics
sample size

INSTRUCTOR ACTIVITY:

1. Explain the role of total suspended solids analysis in the determination of water quality.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of total suspended solids analysis in the determination of water quality.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 26

TOTAL VOLATILE SOLIDS

PURPOSE: *In this module the student will learn to determine the total volatile solids in a sample of wastewater by using the gravimetric method. This analysis measures the organic solids which burn on ignition. Results of the test are used in the design and operation of sludge digesters, vacuum filters and incineration units. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

26.1 Describe the sampling procedures for the total volatile solids analysis.
26.2 Perform the sampling procedures for the total volatile solids analysis.
26.3 Describe the gravimetric method for total volatile solids analysis.
26.4 Perform the total volatile solids analysis.
26.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total volatile solids analyses.
26.6 Plan the laboratory control procedures for monitoring total volatile solids.
26.7 Explain the theory behind the total volatile solids analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
sodium hydroxide, 1*N*	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
burner	x	
desiccator	x	
drying oven	x	
evaporating dish	x	
forceps	x	

EQUIPMENT:
continued

	ANALYSIS	SAMPLING
graduated cylinders, 100 ml	x	
muffle furnace	x	
pH meter	x	
steam bath	x	
support frame for bath	x	
thermometer	x	
water sample bottles with stoppers, 125 ml		x

RESOURCES: 225 387 465 833 866 1033 1034 1125 1326 1336 1370 1461 1473 1623

<<<<<<>>>>>>

OBJECTIVE 26.1: *Describe the sampling procedures for the total volatile solids analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 536; Method for Chemical Analysis of Water and Wastes, p. 282;* and these plant locations for grab and composite samples:

- influent
- screen and grinder effluent
- grit chamber
- primary sedimentation tank
- secondary sedimentation tank
- pond
- first stage digester
- second stage digester
- sludge dewaterer
- solids disposal sight
- effluent

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 26.2:

Perform the sampling procedures for the total volatile solids analysis.

CONDITIONS:

Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 26.3: *Describe the gravimetric method for total volatile solids analysis.*

CONDITIONS: Given a standard reference, the formula for calculating total volatile solids and total volatile solids data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for using a muffle furnace, using a desiccator and handling hot evaporation dishes.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  evaporation
  ignition of residue to constant weight

Describe the procedures for recording data.

Calculate the total volatile solids

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for working with muffle furnaces, using a desiccator and handling hot evaporation dishes.
3. Describe the major steps in the total volatile solids analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating total volatile solids, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when working with muffle furnaces, using a desiccator and handling hot evaporation dishes.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 26.4: *Perform the total volatile solids analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagent.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the total volatile solids and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagent.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.
6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the total volatile solids and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagent.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.

6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 26.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of total volatile solids analyses.*

CONDITIONS: Given references and the results of total volatile solids analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal total volatile solids levels found in these unit processes:
  collection
  screening and grinding
  grit removal
  primary sedimentation
  secondary sedimentation
  pond stabilization
  first stage digestion
  second stage digestion
  sludge dewatering
  solids disposal
  effluent disposal

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:	1. Discuss the reference materials used to determine normal total volatile solids levels. 2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range. 3. Explain why results of analyses may depart from normal levels. 4. Discuss how variations in sampling may produce misleading results. 5. Discuss the effects of abnormal levels on plant operation. 6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.
STUDENT ACTIVITY:	1. Select the references and determine normal total volatile solids levels for each unit process. 2. Describe the actions to take if the results are not within the normal range. 3. Determine why the results of the analysis depart from normal levels. 4. Explain how variations in sampling may produce misleading results. 5. Explain why results of analyses should fall within a certain range. 6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 26.6:	*Plan the laboratory control procedures for monitoring total volatile solids.*
CONDITIONS:	Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.
ACCEPTABLE PERFORMANCE:	The student will: List the tests and measurements for total volatile solids. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total volatile solids.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring total volatile solids.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for total volatile solids.
2. Describe sampling locations and the frequency and methods of analysis for monitoring total volatile solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total volatile solids.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for total volatile solids.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring total volatile solids.
3. Discuss requirements for equipment, storage, records and reports for monitoring total volatile solids.
4. Work in small groups to plan the laboratory control procedures for monitoring total volatile solids.

<<<<<<>>>>>>

OBJECTIVE 26.7: *Explain the theory behind the total volatile solids analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of total volatile solids analysis in the determination of water quality.

Explain how total volatile solids results will be affected by:
  drying time
  filter characteristics
  ignition time
  temperature

INSTRUCTOR ACTIVITY:

1. Explain the role of total volatile solids analysis in the determination of water quality.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of total volatile solids analysis in the determination of water quality.
2. Discuss the interferences.

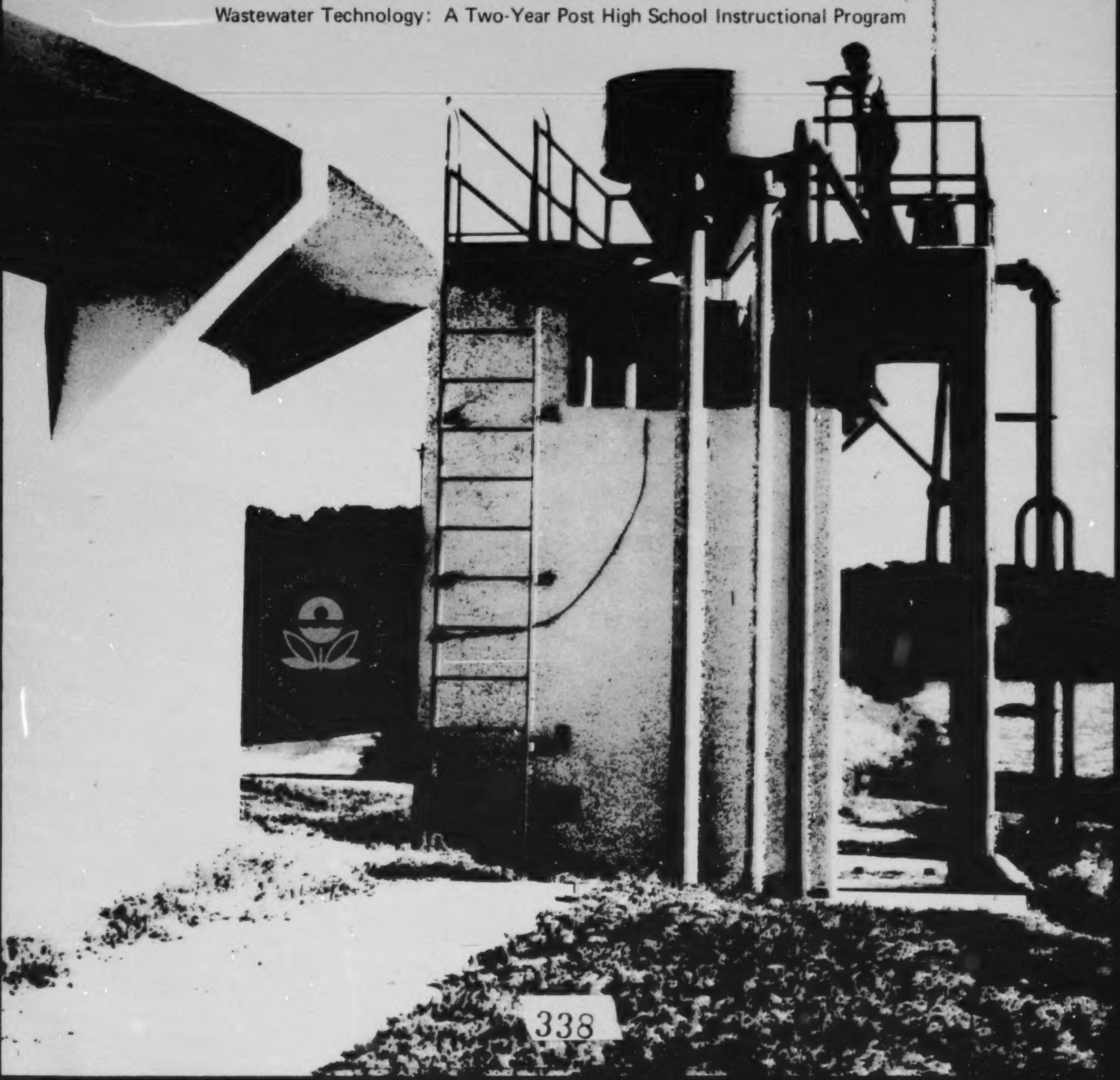
<<<<<<>>>>>>

Volume III

PART G

Laboratory Control for Wastewater Facilities

Wastewater Technology: A Two-Year Post High School Instructional Program



LABORATORY CONTROL FOR WASTEWATER FACILITIES, Part G

Characteristics of Activated Sludge
Sludge Conditioning
Sludge Digester Gas

An Instructor's Guide for Use of Instructional Material
In Wastewater Technology Training Programs

Funded by

US ENVIRONMENTAL PROTECTION AGENCY
Municipal Permits & Operations Division
Water Quality Control Manpower Training Branch
Academic Training Section

Awarded to

CHARLES COUNTY COMMUNITY COLLEGE
La Plata, Maryland

GREENVILLE TECHNICAL COLLEGE
Greenville, South Carolina

LINN-BENTON COMMUNITY COLLEGE
Albany, Oregon

ENVIRONMENTAL SYSTEMS ENGINEERING
Clemson University
Clemson, South Carolina

July 1976

For Information

ON FUNDING OF INSTRUCTIONAL PROGRAMS

Manpower, Planning and Training Branch
MOTD/OWPO
US Environmental Protection Agency
Washington, DC 20460
202-426-7887

ON PROJECT ADMINISTRATION AND CURRICULA DEVELOPMENT

John H. Austin, Professor and Head
Environmental Systems Engineering
Clemson University
Clemson, South Carolina 29631
803-656-3276

ON PROGRAM IMPLEMENTATION

Carl Schwing
Charles County Community College
La Plata, Maryland 20646
301-934-2251

James L. Chocklett
Greenville Technical College
Greenville, South Carolina 29606
803-242-3170

Peter C. Scott
Linn-Benton Community College
Albany, Oregon 97321
503-928-2361

Preface

Since 1970 Charles County Community College, Clemson University, Greenville Technical College and Linn-Benton Community College have been working together to prepare undergraduate students to enter occupations in water and wastewater treatment plant operations and maintenance. Through their efforts a two-year wastewater technology instructional program based on performance objectives has been developed and implemented.

Through a grant from the Environmental Protection Agency called *Criteria for the Establishment of Two-Year Post High School Wastewater Technology Programs (CEWT)* the four colleges set up program criteria and curriculum guidelines which are available in two volumes:

Program Implementation Procedures
Curriculum Guidelines, Criteria for Establishment and Maintenance of Two-Year Post High School Wastewater Technology Programs

As a result of the implementation of the instructional program at Charles County Community College, Greenville Technical College and Linn-Benton Community College, six guides for instructors based on the course descriptions in *Program Implementation Procedures* and the general criterion behaviors of *Curriculum Guidelines* have been prepared. *Laboratory Control for Wastewater Facilities*, printed in seven parts, is the third in the series which includes:

Volume I	*Introduction to Environmental Technology*
Volume II	*Plant Operations for Wastewater Facilities*
Volume III	*Laboratory Control for Wastewater Facilities*
Volume IV	*Management and Supervision Procedures for Wastewater Facilities*
Volume V	*Process Interaction for Wastewater Facilities*
Volume VI	*Advanced Waste Treatment*

ACKNOWLEDGEMENTS

Since the beginning of the project many persons at the four cooperating institutions, as well as outside consultants have participated in the development of this program. Their efforts which have provided source material for this guide have been acknowledged in the volume to which they made major contributions. *Laboratory Control for Wastewater Facilities* has been written and produced by:

Technical Staff

David Wagner, Instructor, Pollution Abatement Technology Department, Charles County Community College

Mary Ann Cashion, Research Technologist, Clemson University
Delores M. Lamb, Teaching Materials Assistant, Clemson University
Robert L. Lord, Research Technologist, Clemson University
Sharon d'Entremont, Student Assistant, Clemson University
Joe F. Allen, Associate Professor, Chemistry, Clemson University
John H. Austin, Professor and Head, Environmental Systems Engineering, Clemson University

Editorial and Production Staff

Ada Louise Steirer, Freelance Editor, Clemson, South Carolina
Charlotte Holmes, Typing Services, Clemson, South Carolina
Marie N. Sims, Project Secretary, Environmental Systems Engineering, Clemson University
Linda Flagg, Typist, Environmental Systems Engineering, Clemson University

Table of Contents

Page
PREFACE iii
PERFORMANCE OBJECTIVES. 1
INTRODUCTION TO MODULES OF INSTRUCTION. 3
GLOSSARY OF VERBS 7

MODULES OF INSTRUCTION

Module A Standard References. Part A
Module B National Pollutant Discharge Elimination System. . . . . . . Part A
Module C Safety . . . . Part A
Module 1 Acidity. . . . . Part B
Module 2 Alkalinity . . . . Part B
Module 3 Chloride . . . . Part B
Module 4 pH . . . . Part B
Module 5 Temperature. . . . . Part B
Module 6 Biochemical Oxygen Demand. . . . . Part C
Module 7 Chemical Oxygen Demand . . . . Part C
Module 8 Chlorine Requirement . . . . Part C
Module 9 Dissolved Oxygen . . . . Part C
Module 10 Fecal Coliform . . . . Part C
Module 11 Total Residual Chlorine. . . . . Part C
Module 12 Color. . . . . Part D
Module 13 Grease . . . . Part D
Module 14 Specific Conductance . . . . Part D
Module 15 Turbidity. . . . . Part D
Module 16 Ammonia Nitrogen . . . . Part E
Module 17 Kjeldahl Nitrogen. . . . . Part E
Module 18 Nitrate Nitrogen . . . . Part E
Module 19 Nitrite Nitrogen . . . . Part E
Module 20 Orthophosphate . . . . Part E
Module 21 Total Phosphorus . . . . Part E
Module 22 Settleable Matter. . . . . Part F
Module 23 Total Solids . . . . Part F
Module 24 Total Dissolved Solids . . . . Part F
Module 25 Total Suspended Solids . . . . Part F
Module 26 Total Volatile Solids. . . . . Part F
Module 27 Characteristics of Activated Sludge. 11
Module 28 Sludge Conditioning. 19
Module 29 Sludge Digester Gas. 27

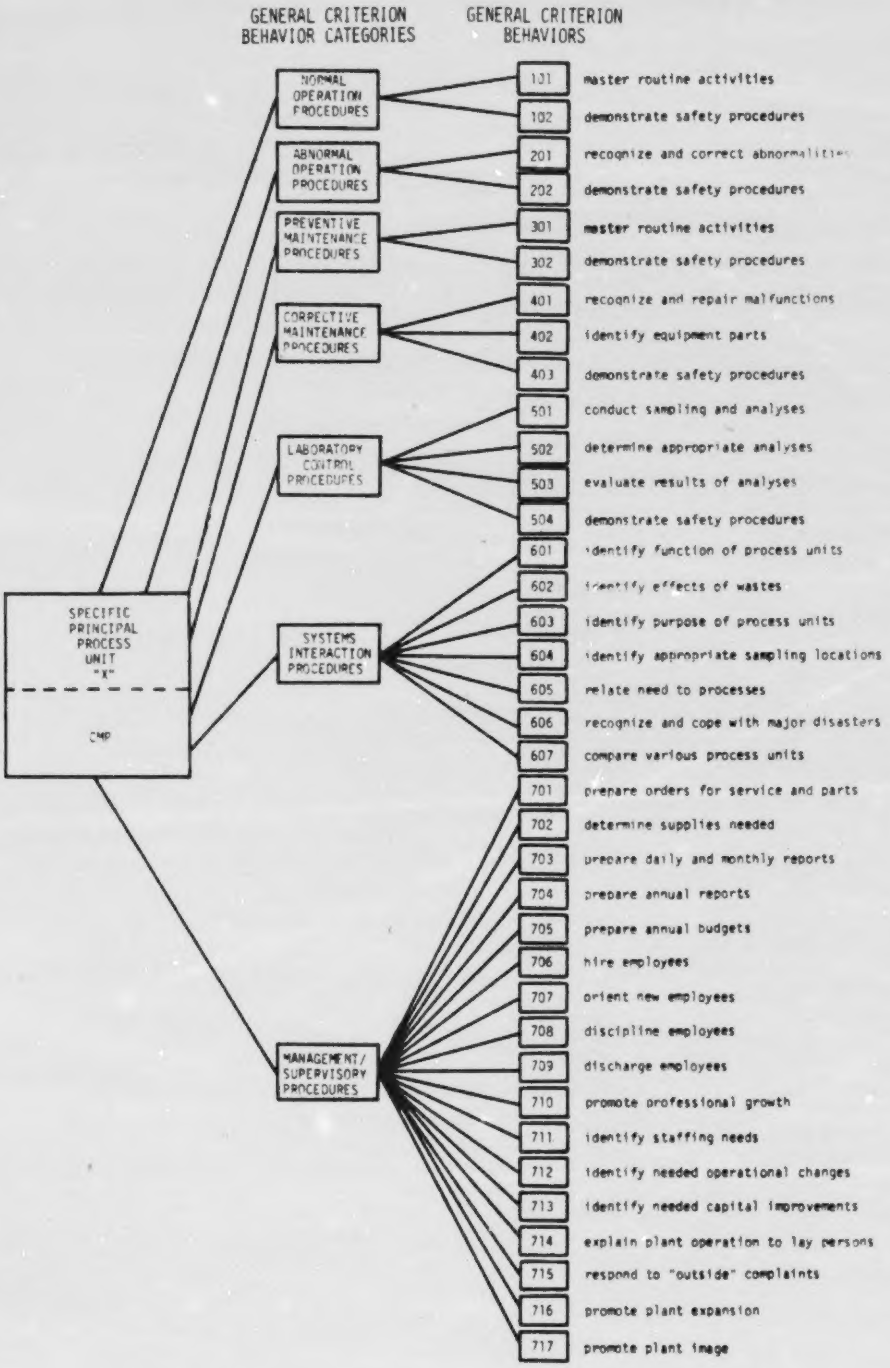

GENERAL CRITERION BEHAVIOR CATEGORIES
GENERAL CRITERION BEHAVIORS
SPECIFIC PRINCIPAL PROCESS UNIT "X"
CMP
NORMAL OPERATION PROCEDURES
ABNORMAL OPERATION PROCEDURES
PREVENTIVE MAINTENANCE PROCEDURES
CORRECTIVE MAINTENANCE PROCEDURES
LABORATORY CONTROL PROCEDURES
SYSTEMS INTERACTION PROCEDURES
MANAGEMENT/ SUPERVISORY PROCEDURES
101 master routine activities
102 demonstrate safety procedures
201 recognize and correct abnormalities
202 demonstrate safety procedures
301 master routine activities
302 demonstrate safety procedures
401 recognize and repair malfunctions
402 identify equipment parts
403 demonstrate safety procedures
501 conduct sampling and analyses
502 determine appropriate analyses
503 evaluate results of analyses
504 demonstrate safety procedures
601 identify function of process units
602 identify effects of wastes
603 identify purpose of process units
604 identify appropriate sampling locations
605 relate need to processes
606 recognize and cope with major disasters
607 compare various process units
701 prepare orders for service and parts
702 determine supplies needed
703 prepare daily and monthly reports
704 prepare annual reports
705 prepare annual budgets
706 hire employees
707 orient new employees
708 discipline employees
709 discharge employees
710 promote professional growth
711 identify staffing needs
712 identify needed operational changes
713 identify needed capital improvements
714 explain plant operation to lay persons
715 respond to "outside" complaints
716 promote plant expansion
717 promote plant image

Figure 1: Relationship of general criterion behaviors (performance objectives) to the general categories and composite model plant (CMP).

Performance Objectives

When the treatment plant operators, educators, consultants and representatives from professional water pollution control organizations came together to develop an effective instructional program, they recommended the use of performance or behavioral objectives because such objectives clearly outline:

1. What the student is expected to do as a result of the instructional program.
2. The conditions under which the student shall do it.
3. The standard of performance.

COMPOSITE MODEL PLANT

First, they developed a composite model plant (CMP) of twenty-two process units which is really many wastewater treatment plants in one model. Such a mix of process units seldom occurs in a treatment plant, but if a student becomes competent in the operation and management of the CMP he should be able to perform successfully in any treatment plant.

TASK ANALYSIS

Next, to ensure that the materials were specifically tailored to what the operator does on the job, a task analysis was conducted. They found that the tasks which an operator performs fell into seven general categories which were further divided into 37 tasks or general behaviors. (See figure 1, page vi.) The tasks were organized under:

1. Normal Operation Procedures. These include routine operating activities that do not vary significantly from day to day and that are designed to keep the plant functioning within a normal range of values. For example, the employee conducts routine samplings of the primary sludge and inspects pumping equipment and the wastestream to verify that the process is functioning properly.

2. Abnormal Operation Procedures. These include activities of the plant employee that result from unusual and undesirable conditions of the wastestream. The abnormal procedures enable the plant employee to recognize when the wastestream is abnormal and to return it to an acceptable, normal condition. An abnormal wastestream results when a normal operation procedure is not properly applied, a corrective maintenance procedure is needed or management/supervisory procedures are poor. For example, the plant employee should recognize that a black septic primary sludge sample is an abnormal condition of the wastestream and take appropriate action.

3. Preventive Maintenance Procedures. These include routine maintenance activities of the plant employee which prevent major equipment breakdown and subsequent corrective maintenance. For example, the employee would lubricate bearings and other moving parts, replace worn components and adjust components of the primary sludge pumps.

4. Corrective Maintenance Procedures. These include maintenance activities of the plant employee that usually result from the breakdown or malfunction of a unit of equipment or a component. For example, the employee would notice whether the primary sludge pump is malfunctioning and know when and how to correct the disorder or when and how to refer the problem to plant maintenance personnel.

5. Laboratory Control Procedures. These include special and routine activities relating to laboratory analysis, the specification of sampling procedures and locations and the general management of the laboratory facilities. For example, the employee would collect primary sludge samples and conduct the analyses.

6. Systems Interaction Procedures. These include activities of the plant employee which relate the functioning of specific units of equipment to other process units and to the system as a whole. For example, the employee would determine how the effective functioning of the primary sludge pumps relates to digester performance.

7. Management/Supervisory Procedures. These include activities relating to employment practices, record keeping, plant operation policy and the establishment of a constructive and realistic rapport between the plant and the community it serves. For example, the employee would keep records on primary sludge pumping, keep an inventory of spare parts and evaluate the adequacy of maintenance procedures by shift personnel.

CURRICULUM DESIGN

After deciding what process equipment an operator must operate and maintain, and finding out what an operator does through the task analysis, they listed the objectives a student must master to successfully operate and manage a treatment plant. For example, the student will describe and perform the normal inspection procedure for the primary sedimentation unit including frequency of inspection, conditions to look for and the actions he should take.

INSTRUCTOR'S GUIDES

The next step was the design of manuals to guide the instructor. In the guides varied learning activities and imaginative innovations which produce more learning that traditional teaching methods are emphasized. The instructional suggestions do not need to be followed slavishly, but should be modified and improved as much as possible.

The instructor's goal is to achieve the objectives of the curriculum by selecting activities which suit the student's needs and help him to master all the information and skills in the course. The most effective learning occurs when the student is a participant in the learning process, not a spectator.

An instructor should use learning activities which approximate the situations which the student will meet *in the treatment plant.* If it is not possible to teach in a treatment plant, *simulated situations* should be set up in the workshop or classroom so that the student can solve rather than discuss problems. *Group discussion* stimulated by *visual materials* is an effective learning technique. Lecturing, however, is inefficient. Because the student is not actively involved during a lecture, the instructor should use lectures sparingly.

Introduction to Modules of Instruction

In this instructor's guide the topics and ideas are presented as a series of modules, based on the general objectives stated in the course descriptions for Laboratory Control I, II and III which are found in the *Program Implementation Procedures* of the *CEWT Program*. Each module is organized around seven objectives common to all analyses. Three preliminary modules introduce students to the standard references, the National Pollutant Discharge Elimination System and general laboratory safety.

In *Laboratory Control for Wastewater Facilities* related analyses are grouped together. For example, modules on measuring settleable matter, total solids, dissolved solids, suspended solids and volatile solids appear in one manual.

Each module is designed so that it can be used as a guide for a minicourse in a laboratory analysis. Material in the modules is appropriate for teaching students with no experience in a wastewater treatment plant laboratory, as well as for upgrading the skills of treatment plant operators.

Instructors are urged to group the modules to suit their individual curriculum needs and instructional situations. For example, by grouping objectives 3 and 4 from all modules, an instructor could develop a course on performing analyses. Or, objective 7 can be omitted if the student does not need to know the theory behind the analysis.

INSTRUCTIONAL SETTING

During training the student should have access to a laboratory with equipment and supplies which is typical of a one to 10 mgd wastewater treatment plant.

PURPOSE OF THE MODULES

The modules in *Laboratory Control for Wastewater Facilities* help the student to learn to perform the analyses used to monitor the wastestream for process control and for reporting to regulatory agencies. Sampling, analysis, determining operational efficiency and theory are included.

STUDENT PREREQUISITES

Completion of Introduction to Environmental Technology, and courses in basic mathematics, biology and chemistry qualify the student to enter Laboratory Control for Wastewater Facilities. Concurrent courses in technical report writing and applied mathematics are suggested. (See pages 7 to 19 of *Program Implementation Procedures*.)

TERMINAL OBJECTIVE

When the student has completed the modules of instruction in this course, he should be able to:

1. Describe the sampling procedure for the analysis.
2. Perform the sampling procedure.
3. Describe the method of analysis.
4. Perform the analysis.
5. Determine the operational efficiency of a process unit or combination of process units by interpreting the results of analyses.
6. Plan laboratory control procedures for monitoring.
7. Explain the theory behind the analysis.

RESOURCES

The listing of instructional resources suggests materials now available to instructors to accomplish the desired performance in the student. The resource numbers referred to in the modules are keyed to *Water Quality Instructional Resources Information System (IRIS)* which is available from:

National Training Center
MOTD/OWPO
US Environmental Protection Agency
Cincinnati, OH 45268
513-684-7501

Suggestions for selecting audio-visual equipment can be found in *Selecting Audio-Visual Equipment* and *Selecting Instructional Media and Instructional Systems* available from:

Middle Atlantic Applied Technology Inst.
Charles County Community College
La Plata, MD 20646

If suitable materials are not available, instructors are urged to develop their own resources.

FORMAT OF THE MODULES

The module begins with a statement of purpose which explains what the student will be studying. Next, prerequisite modules and all the objectives in the module follow. A list of chemicals and equipment for sampling and analysis and the resources keyed to *IRIS* complete the introductory material.

Objectives. The objectives bring the student to the performance level required by the terminal objective. The instructor's evaluation of the student is based solely on what is stated in the objective.

Conditions. The conditions define the circumstances under which the student performs and is evaluated and lists the information, equipment and assistance to which the student will have access. The best available learning and testing conditions should be used. For example, demonstrations on film have less impact on students than demonstrations by the instructor in a wastewater treatment plant laboratory.

The page numbers for the references listed in the conditions refer the student to the editions specified in Public Law 92-500:

Standard Methods, 13th edition, 1971

Annual Book of Standards, Part 23, Water, Atmospheric Analysis, 1972

Methods for Chemical Analysis of Water and Wastes, 1971

Acceptable Performance. The acceptable performance expands the objective and details the steps a student must follow to reach the objective. To move on to the next objective the student should score at least 70% on each

step listed under acceptable performance. Practice on the techniques must continue until the student reaches the standard called for in the standard reference being used. In this section the instructor will find the main topics of his lesson plan and for the evaluation of the student's performance.

Instructor Activity. The instructor should get to know his class by working with small groups and with each student. He should encourage students to learn from each other as they work together. He should involve the student in the instructional and learning process. Group discussion and interaction should be emphasized. Films, filmstrips, slides, tapes, transparencies and case histories should be used. Instructional activities are paired numerically with student activities.

Student Activity. This is a listing of activities which the student will take part in, in order to accomplish the specified performance.

EVALUATION TECHNIQUE

The instructor may use or adapt the learning activities listed under instructor activity and student activity as evaluation techniques. The technique chosen should reflect what the objective asks the student to do. For example, if a student is asked to *describe*, the evaluation technique is a *description*. The student should be evaluated under the conditions and to the performance level required for each objective.

Glossary of Verbs

The glossary of verbs is included so that the instructor will know exactly what the student is being asked to do to meet his objective. The list includes verbs used in the objectives and the acceptable performance sections of the modules, as well as in the instructor and student activities.

	DEFINITION	APPLICATION
CHECK	To inspect and ascertain the condition of, especially in order to determine that the condition is satisfactory.	Check the flow chart which the student has prepared for the analysis.
COMMENT ON	To express an opinion or attitude about what has been seen or heard.	Comment on the safety procedures used.
COMPARE	To examine the character or qualities of, especially for the purpose of discovering resemblances or differences.	Compare the two methods of analysis.
DEFINE	To determine the essential qualities or precise meaning of.	Define acidity.
DEMONSTRATE	To illustrate or explain in an orderly and detailed way with many examples, specimens and particulars.	Demonstrate the procedure for preparing and identifying a sample container.
DESCRIBE	To represent by words written or spoken for the knowledge or understanding of others; to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.	Describe the sampling procedures for the acidity analysis.

	DEFINITION	APPLICATION
DETERMINE	To come to a decision as the result of investigation or reasoning. To settle by choice of alternatives or possibilities.	Determine the operational efficiency of a process unit or combination of process units by interpreting the results of acidity analyses.
DEVELOP	To produce or generate.	Develop a flow chart for the sampling procedures.
DISCUSS	To talk about, to present in detail, to exchange views or information about.	Discuss conditions to avoid while sampling and transporting the sample.
DISPLAY	To spread before the view.	Display and name the standard references.
EVALUATE	To examine and make a judgment about quality, significance, amount, degree or condition of.	Evaluate the conditions which guarantee that a representative sample is obtained.
EXAMINE	To inspect closely.	Examine and note the kinds of information used to complete a discharge monitoring report form.
EXPLAIN	To make plain or clear; to present in detail.	Explain the theory behind the acidity analysis.
IDENTIFY	To associate in such a way as to have unity; to make correlative with something.	Identify actions and situations which violate laboratory rules.
LIST	To enumerate or specify.	List this information to appear on each container: date, place, time, name of person who collected sample.
LOCATE	To determine or indicate the place, site or limits of.	Locate the analysis in table 1.
NAME	To mention or identify by naming.	Name and describe the sampling equipment needed at each location.
NOTE	To take due or special notice of.	Note the names of the standard references.
OBSERVE	To pay careful, directed, analytical attention to.	Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

	DEFINITION	APPLICATION
PERFORM	To carry out an action or pattern of behavior. (Implies an act for which a process or pattern of movement has already been established, especially one calling for skill or precision, or for the assignment or assumption of responsibility.)	Perform the sampling procedures for the acidity analysis.
PLAN	To devise a method for making or doing something or achieving an end.	Plan the laboratory control procedures for monitoring acidity.
POINT OUT	To direct someone's attention to.	Point out conditions to avoid in sampling and transporting the sample at each location.
PRESENT	To offer to view; show.	Present data for various types of wastewater.
SELECT	To choose something from a number or group usually by fitness, excellence or other distinguishing feature.	Select and use the sampling equipment.
STATE	To express in words.	State the maximum holding time.

Module 27

CHARACTERISTICS OF ACTIVATED SLUDGE

PURPOSE: *In this module the student will learn to determine the characteristics of activated sludge using the gravimetric method. This analysis measures the volume of activated sludge that will settle after the sample stands undisturbed for a set length of time. Operators base changes in the returned-sludge rate and decisions about wasting sludge on data from this test. Results of the settled volume analysis on mixed liquors are used in calculating the sludge volume index (SVI) and sludge density index (SDI). READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

27.1 Describe the sampling procedures for the activated sludge analysis.
27.2 Perform the sampling procedures for the activated sludge analysis.
27.3 Describe the gravimetric method for activated sludge analysis.
27.4 Perform the activated sludge analysis.
27.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of activated sludge analyses.
27.6 Plan the laboratory control procedures for monitoring activated sludge.
27.7 Explain the theory behind the activated sludge analysis.

EQUIPMENT:

	ANALYSIS	SAMPLING
graduated cylinders, 1000 ml		x
stirring rods	x	
stopwatch	x	
storage bottles, 4 liter		x
thermometer	x	

RESOURCES: 225 387 465 545 546 547 584 833 866 1033 1034 1125
1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 27.1: *Describe the sampling procedures for the activated sludge analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 560, p. 561* and these plant locations for grab samples:
- aerator
- secondary sedimentation tank

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:
- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample.

Describe the best time and conditions for obtaining a representative sample.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample.
4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.

3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 27.2: *Perform the sampling procedures for the activated sludge analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and the plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures in a treatment plant at each sampling location.

<<<<<<>>>>>>

OBJECTIVE 27.3: *Describe the gravimetric method for activated sludge analysis.*

CONDITIONS: Given a standard reference, the formulas for calculating settled volume of sludge, sludge density index and sludge volume index and data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for collecting samples.

Explain how these safety precautions protect employees.

List the major step in the analysis:
settling of activated sludge

Describe the procedures for recording data.

Calculate the settled volume of sludge, the sludge density index and the sludge volume index.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for collecting samples.
3. Describe the major step in the characteristics of activated sludge analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating settled volume of sludge, the sludge density index and the sludge volume index, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when collecting samples.
3. List the major step in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 27.4: *Perform the activated sludge analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the settled volume of sludge, the sludge density index and the sludge volume index and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the sample for the analysis.
3. Perform the analysis on a sample.
4. Observe the student demonstrating the analysis in a dry run in the laboratory.
5. Observe the student performing the analysis in the laboratory.
6. Explain how to record data, calculate the settled volume of sludge, the sludge density index and the sludge volume index and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the sample for the analysis.
3. Observe the instructor demonstrating the analysis.
4. Demonstrate the analysis in a dry run in the laboratory.
5. Perform the analysis.
6. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 27.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of activated sludge analyses.*

CONDITIONS: Given references and the results of activated sludge analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal activated sludge levels found in these unit processes:
  aeration
  secondary sedimentation

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal activated sludge levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal activated sludge levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.

4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 27.6: *Plan the laboratory control procedures for monitoring activated sludge.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for the characteristics of activated sludge.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring the characteristics of activated sludge.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring the characteristics of activated sludge.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for the characteristics of activated sludge.
2. Describe sampling locations and the frequency and methods of analysis for monitoring the characteristics of activated sludge.
3. Discuss requirements for equipment, storage, records and reports for monitoring the characteristics of activated sludge.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests used for the characteristics of activated sludge.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring the characteristics of activated sludge.
3. Discuss requirements for equipment, storage, records and reports for monitoring the characteristics of activated sludge.
4. Work in small groups to plan the laboratory control procedures for monitoring the characteristics of activated sludge.

<<<<<<>>>>>>

OBJECTIVE 27.7: *Explain the theory behind the activated sludge analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the significance of settling characteristics in the activated sludge process.

Explain how sludge results will be affected by:
- agitation
- pH
- temperature
- time between sampling and the start of the analysis

Discuss the relationship between settled volume and returned-sludge rate.

INSTRUCTOR ACTIVITY:

1. Explain the significance of settling characteristics in the activated sludge process.
2. Explain the causes and effects of interferences.
3. Explain the relationship between settled volume and returned-sludge rate.

STUDENT ACTIVITY:

1. Discuss the significance of settling characteristics in the activated sludge process.
2. Discuss the interferences.
3. Explain the relationship between settled volume and returned-sludge rate.

<<<<<<>>>>>>

Module 28

SLUDGE CONDITIONING

PURPOSE: *In this module the student will learn to determine the effectiveness of sludge conditioning measures by using the Buchner funnel method. This analysis measures the amount of chemicals required for dewatering sludge by adding different combinations of coagulants to discover which will work most effectively in the treatment plant. The quantity of chemicals varies with time. This test promotes economical operation of the treatment process. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

28.1 Describe the sampling procedures for the sludge conditioning analysis.
28.2 Perform the sampling procedures for the sludge conditioning analysis.
28.3 Describe the Buchner funnel method for sludge conditioning analysis.
28.4 Perform the sludge conditioning analysis.
28.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of sludge conditioning analyses.
28.6 Plan the laboratory control procedures for monitoring sludge conditioning.
28.7 Explain the theory behind the sludge conditioning analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
coagulants	x	
distilled water	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
Buchner funnels	x	

EQUIPMENT:
continued

	ANALYSIS	SAMPLING
filter flasks	x	
filter paper	x	
graduated cylinders, 100 ml	x	
storage bottles, 4 liter		x
vacuum pump	x	

RESOURCES: 225 387 465 591 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 28.1: *Describe the sampling procedures for the sludge conditioning analysis.*

CONDITIONS: Given *Sludge Dewatering*, Manual of Practice No. 20, Water Pollution Control Federation, page 26 and these plant locations for grab and composite samples:

secondary sedimentation tank
first stage digester
second stage digester

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

- date
- place
- time
- name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

State the maximum holding time.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.

4. Describe the best conditions for obtaining a representative sample.
5. State the maximum holding time.
6. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. State the maximum holding time.
6. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 28.2: *Perform the sampling procedures for the sludge conditioning analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab and composite samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.
5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 28.3: *Describe the Buchner funnel method for sludge conditioning analysis.*

CONDITIONS: Given a standard reference, the formula for calculating sludge filterability and sludge filterability data.

ACCEPTABLE PERFORMANCE: The student will:

Prepare or obtain a list of equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for vacuum filtering with Buchner funnels.

Explain how these safety precautions protect employees.

List the major step in the analysis:
  filtration of the sample

Describe the procedures for recording data.

Calculate the sludge filterability.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for vacuum filtering with Buchner funnels.
3. Describe the major step in the sludge conditioning analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formula for calculating sludge filterability, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.

2. State the safety precautions followed when vacuum filtering with Buchner funnels.
3. List the major step in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 28.4: *Perform the sludge conditioning analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the sludge filterability and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare the sample for the analysis.
3. Perform the analysis on a sample.
4. Observe the student demonstrating the analysis in a dry run in the laboratory.
5. Observe the student performing the analysis in the laboratory.
6. Explain how to record data, calculate the sludge filterability and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare the sample for the analysis.
3. Observe the instructor demonstrating the analysis.
4. Demonstrate the analysis in a dry run in the laboratory.
5. Perform the analysis.
6. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 28.5: *Determine the operational efficiency of a process unit or combination of process units by interpreting the results of sludge conditioning analyses.*

CONDITIONS: Given references and the results of sludge conditioning analyses.

ACCEPTABLE PERFORMANCE: The student will:

Select the references and determine normal sludge conditioning levels found in these unit processes:
- secondary sedimentation
- first stage digestion
- second stage digestion

Describe what to do if the results of the analyses are not within the normal range, including:
- increasing the frequency of testing
- sampling at different locations
- reporting to supervisors

Determine which of these factors causes a departure from normal levels:
- changes in the composition of the wastestream
- changes in treatment
- errors in sampling
- errors in laboratory technique
- errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal sludge conditioning levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the

student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal sludge conditioning levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 28.6: *Plan the laboratory control procedures for monitoring sludge conditioning.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for sludge conditioning.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring sludge conditioning.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring sludge conditioning.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for sludge conditioning.
2. Describe sampling locations and the frequency and methods of analysis for monitoring sludge conditioning.

3. Discuss requirements for equipment, storage, records and reports for monitoring sludge conditioning.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for sludge conditioning.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring sludge conditioning.
3. Discuss requirements for equipment, storage, records and reports for monitoring sludge conditioning.
4. Work in small groups to plan the laboratory control procedures for monitoring sludge conditioning.

<<<<<<>>>>>>

OBJECTIVE 28.7: *Explain the theory behind the sludge conditioning analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of sludge conditioning analysis in wastewater treatment plant operations.

Explain how sludge conditioning results will be affected by:
amount of coagulants
concentration of coagulants
order in which coagulants are added
volumes of coagulants

INSTRUCTOR ACTIVITY:

1. Explain the role of sludge conditioning analysis in wastewater treatment plant operations.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of sludge conditioning analysis in wastewater treatment plant operations.
2. Discuss the interferences.

<<<<<<>>>>>>

Module 29

SLUDGE DIGESTER GAS

PURPOSE: *In this module the student will learn to determine the composition of sludge digester gas by using the volumetric method. This analysis measures the volume of carbon dioxide and oxygen by absorption and hydrogen by oxidation to water. Combustion then releases carbon dioxide equivalent to the methane present. The remaining gas is nitrogen. The relative amounts of these gases indicate the efficiency of the process and suggest process control procedures to improve digester operation. READ PAGES 1 TO 10 BEFORE USING THIS MODULE.*

PREREQUISITES: *Modules A, B and C on the three standard references for wastewater analyses, the National Pollutant Discharge Elimination System and safety in the laboratory, printed in LABORATORY CONTROL FOR WASTEWATER FACILITIES, PART A.*

OBJECTIVES:

29.1 Describe the sampling procedures for the sludge digester gas analysis.
29.2 Perform the sampling procedures for the sludge digester gas analysis.
29.3 Describe the volumetric method for sludge digester gas analysis.
29.4 Perform the sludge digester gas analysis.
29.5 Determine the operational efficiency of a process unit or combination of process units by interpreting the results of sludge digester gas analyses.
29.6 Plan the laboratory control procedures for monitoring sludge digester gas.
29.7 Explain the theory behind the sludge digester gas analysis.

CHEMICALS:

	ANALYSIS	SAMPLING
distilled water	x	
mercury or sodium sulfate		x
oxygen gas	x	
potassium hydroxide	x	
pyrogallol	x	
sulfuric acid	x	

EQUIPMENT:

	ANALYSIS	SAMPLING
balance	x	
beakers, 250 ml	x	
displacement collectors		x
gas-analysis apparatus	x	
water-jacketed gas buret with leveling bulb		
carbon dioxide-absorption pipet		
oxygen-absorption pipet		
cupric oxide-hydrogen oxidation assembly		
catalytic methane-oxidation assembly		
leveling bulb		
source of current	x	
volumetric flasks, 1 liter	x	

RESOURCES: 225 387 465 833 866 1033 1034 1125 1326 1336 1370 1461 1473

<<<<<<>>>>>>

OBJECTIVE 29.1: *Describe the sampling procedures for the sludge digester gas analysis.*

CONDITIONS: Given *Standard Methods for the Examination of Water and Wastewater, p. 541* and these plant locations for grab samples:

first stage digester
second stage digester

ACCEPTABLE PERFORMANCE: The student will:

Describe the routine preparation of sample containers.
List this information to appear on each container:

date
place
time
name of person who collected the sample

Name and describe the sampling equipment needed at each location.

Explain conditions to avoid while sampling and transporting the sample from each location.

Describe the best time and conditions for obtaining a representative sample from each location.

INSTRUCTOR ACTIVITY:

1. Describe the procedure for preparing and identifying a sample container.
2. Describe the sampling equipment.
3. Point out conditions to avoid in sampling and transporting the sample at each location.
4. Describe the best conditions for obtaining a representative sample.
5. Ask the student to develop a flow chart for the sampling procedures.

STUDENT ACTIVITY:

1. Describe the preparation and identification of sample containers.
2. List and describe the sampling equipment.
3. Discuss conditions to avoid while sampling and transporting the sample.
4. Evaluate the conditions which guarantee that a representative sample is obtained.
5. Develop a flow chart for the sampling procedures.

<<<<<<>>>>>>

OBJECTIVE 29.2: *Perform the sampling procedures for the sludge digester gas analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for grab samples.

ACCEPTABLE PERFORMANCE: The student will:

Prepare and label a sample container.

Select and use the sample equipment.

Obtain a sample from each location.

Transport the sample to the laboratory.

INSTRUCTOR ACTIVITY:

1. Demonstrate the procedure for preparing and identifying a sample container.
2. Perform the sampling procedure and identification of sample container at each sampling location.
3. Demonstrate a method for transporting the sample to the laboratory.
4. Observe the student demonstrating the sampling procedures in a dry run in a treatment plant.

5. Observe the student performing the sampling procedures at each location in a treatment plant.

STUDENT ACTIVITY:

1. Prepare and label a sample container.
2. Select and use the sampling equipment, explaining his actions.
3. Transport the sample to the laboratory.
4. Demonstrate the sampling procedures in a dry run in the laboratory.
5. Perform and explain the sampling procedures at each location in a treatment plant.

<<<<<<>>>>>>

OBJECTIVE 29.3:

Describe the volumetric method for sludge digester gas analysis.

CONDITIONS:

Given a standard reference, the formulas for calculating sludge digester gas and sludge digester gas data.

ACCEPTABLE PERFORMANCE:

The student will:

Prepare or obtain a list of chemicals, equipment and analytical supplies needed to perform the analysis.

Describe the safety procedures for transferring gas samples, handling acids and bases, using absorption pipets, working with gas burets and burning gas.

Explain how these safety precautions protect employees.

List the major steps in the analysis:
  carbon dioxide absorption
  oxygen absorption
  hydrogen oxidation
  methane oxidation

Describe the procedures for recording data.

Calculate the sludge digester gas.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to obtain a list of the chemicals and equipment for the analysis.
2. Discuss case histories of laboratory accidents which have occurred during analysis. Demonstrate the safety procedures for transferring gas samples, handling acids and bases, using absorption pipets, working with gas burets and burning gas.

3. Describe the major steps in the sludge digester gas analysis.
4. Explain the procedures for recording data.
5. Check the flow chart for the analysis which the student has prepared.
6. Present the formulas for calculating sludge digester gas, data from the analysis and calculations using this data.

STUDENT ACTIVITY:

1. Obtain a list of chemicals and equipment for the analysis.
2. State the safety precautions followed when transferring gas samples, handling acids and bases, using absorption pipets, working with gas burets and burning gas.
3. List the major steps in the analysis.
4. List the procedures for recording data.
5. Develop a flow chart for the analysis.
6. Perform the calculations.

<<<<<<>>>>>>

OBJECTIVE 29.4: *Perform the sludge digester gas analysis.*

CONDITIONS: Given a standard reference, a laboratory with equipment and supplies, the flow chart which the student has developed and plant locations for samples.

ACCEPTABLE PERFORMANCE: The student will:

Set up the equipment.

Prepare and standardize the reagents.

Prepare the sample.

Perform the analysis on a sample from a plant location.

Record data, calculate the sludge digester gas and complete the report forms.

INSTRUCTOR ACTIVITY:

1. Demonstrate how to set up the equipment for the analysis.
2. Demonstrate how to prepare and standardize the reagents.
3. Demonstrate how to prepare the sample for the analysis.
4. Perform the analysis on a sample.
5. Observe the student demonstrating the analysis in a dry run in the laboratory.

6. Observe the student performing the analysis in the laboratory.
7. Explain how to record data, calculate the sludge digester gas and complete the report forms.

STUDENT ACTIVITY:

1. Assemble the equipment.
2. Prepare and standardize the reagents.
3. Prepare the sample for the analysis.
4. Observe the instructor demonstrating the analysis.
5. Demonstrate the analysis in a dry run in the laboratory.
6. Perform the analysis.
7. Record data and fill in the report forms.

<<<<<<>>>>>>

OBJECTIVE 29.5:

Determine the operational efficiency of a process unit or combination of process units by interpreting the results of sludge digester gas analyses.

CONDITIONS:

Given references and the results of sludge digester gas analyses.

ACCEPTABLE PERFORMANCE:

The student will:

Select the references and determine normal sludge digester gas levels found in these unit processes:
  first stage digestion
  second stage digestion

Describe what to do if the results of the analyses are not within the normal range, including:
  increasing the frequency of testing
  sampling at different locations
  reporting to supervisors

Determine which of these factors causes a departure from normal levels:
  changes in the composition of the wastestream
  changes in treatment
  errors in sampling
  errors in laboratory technique
  errors in calculations

Discuss how variations in sampling may produce misleading results.

Explain why results of the analyses should fall within a certain range.

Determine whether the unit processes are operating at maximum efficiency.

INSTRUCTOR ACTIVITY:

1. Discuss the reference materials used to determine normal sludge digester gas levels.
2. Discuss additional laboratory tests and different sampling locations and schedules when results are not within the normal range.
3. Explain why results of analyses may depart from normal levels.
4. Discuss how variations in sampling may produce misleading results.
5. Discuss the effects of abnormal levels on plant operation.
6. Present data for various types of wastewater. Ask the student to determine whether the unit processes are operating at maximum efficiency.

STUDENT ACTIVITY:

1. Select the references and determine normal sludge digester gas levels for each unit process.
2. Describe the actions to take if the results are not within the normal range.
3. Determine why the results of the analysis depart from normal levels.
4. Explain how variations in sampling may produce misleading results.
5. Explain why results of analyses should fall within a certain range.
6. Determine from data whether the unit processes are operating at maximum efficiency.

<<<<<<>>>>>>

OBJECTIVE 29.6: *Plan the laboratory control procedures for monitoring sludge digester gas.*

CONDITIONS: Given a standard reference, Public Law 92-500, "Guidelines Establishing Test Procedures for Analysis of Pollutants" and information about treatment plant layout, types of treatment, flow rates and sources of wastewater.

ACCEPTABLE PERFORMANCE: The student will:

List the tests and measurements for sludge digester gas.

Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring sludge digester gas.

Determine requirements for:
  library
  records and reports
  storage for equipment and supplies
  support equipment
  test equipment

Prepare laboratory control reports and procedures for monitoring sludge digester gas.

INSTRUCTOR ACTIVITY:

1. List the tests and measurements for sludge digester gas.
2. Describe sampling locations and the frequency and methods of analysis for monitoring sludge digester gas.
3. Discuss requirements for equipment, storage, records and reports for monitoring sludge digester gas.
4. Divide students into groups to prepare laboratory control procedures.

STUDENT ACTIVITY:

1. State the measurements and tests for sludge digester gas.
2. Develop a checklist of sampling locations and the frequency and methods of analysis for monitoring sludge digester gas.
3. Discuss requirements for equipment, storage, records and reports for monitoring sludge digester gas.
4. Work in small groups to plan the laboratory control procedures for monitoring sludge digester gas.

<<<<<<>>>>>>

OBJECTIVE 29.7: *Explain the theory behind the sludge digester gas analysis.*

CONDITIONS: Given personal notes.

ACCEPTABLE PERFORMANCE: In technical and nontechnical terms the student will:

Discuss the role of sludge digester gas analysis in wastewater treatment plant operations.

Explain how sludge digester gas results will be affected by:
  leaky stopcocks or connections
  other combustible gases

INSTRUCTOR ACTIVITY:

1. Explain the role of sludge digester gas analysis in wastewater treatment plant operation.
2. Explain the causes and effects of interferences.

STUDENT ACTIVITY:

1. Discuss the role of sludge digester gas analysis in wastewater treatment plant operation.
2. Discuss the interferences.

<<<<<<>>>>>>